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Battelle Columbus Labs, Ohio

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ENVIRONMENTAL MONITORING NEAR INDUSTRIAL SITES TRICHLOROETHYLENE

AUGUST 1977

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF TOXIC SUBSTANCES
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16. ABSTRACT

The levels of trichloroethylene (TCE) in various environmental media were determined at four production sites, one user site, and a background site. The ambient air level was determined on-site by direct injection of the ambient air into a gas chromatograph followed by detection and quantification with an electron capture detector. Water, soil, and sediment samples were returned to Battelle for analyses. For the analyses of water samples, TCE was sparged from the water collected on a trap material using a commercial liquid sample concentrator. The trapped organic material was then backflushed onto a gas chromatograph column which was connected to an electron capture detector used to quantify the TCE in the original sample. A similar technique was used for the quantification of TCE in soil and sediment. The results from the analyses and detailed descriptions of the sampling locations are given and keyed to site maps. Considerable variation was observed in the maximum downwind levels of TCE at various production plants. Concentrations in ambient air ranged from less than 1 ppb to 270 ppb. Concentrations in surface water in the vicinity of production and user plants was even more variable ranging from fractions of a ppb to over 5 ppm. Concentrations in soil and sediment range from the limits of detection to over 100 ppb.

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TRICHLOROETHYLENE

August 1977

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EXECUTIVE SUMMARY

The levels of trichloroethylene in various environmental media were determined at four production sites, one user site, and a background site. The following sites were monitored:

Dow Chemical Co., U.S.A.	Freeport, Texas
PPG Industries, Inc.	Lake Charles, Louisiana
Ethyl Corporation.	Baton Rouge, Louisiana
Hooker Chemical Corporation. . .	Taft, Louisiana
Boeing Company (User Site) . . .	Seattle, Washington
St. Francis National Forest. . . (Background Site)	Helena, Arkansas

Approximately 2 days were devoted to monitoring ambient air levels for trichloroethylene and collecting water, soil, and sediment samples at each site. The samples were returned to Battelle-Columbus Laboratories for analyses. The ambient air level of trichloroethylene was determined on-site by direct injection of the ambient air into a gas chromatograph followed by detection and quantification with an electron capture detector.

For the analyses of water samples, the trichloroethylene was sparged from the water and collected on a trap material using a commercial liquid sample concentrator. The trapped organic material was then back-flushed onto a gas chromatograph column which was connected to an electron capture detector used to quantify the trichloroethylene in the original sample. A similar technique was used for the quantification of trichloroethylene in soil and sediment but the apparatus was not of commercial design.

For each site, a map is presented with sampling points indicated. The results from the analyses of the samples and detailed descriptions of the sampling locations are given and are keyed to the site map.

Considerable variation was observed in the maximum downwind levels of trichloroethylene at various production plants. Concentrations of trichloroethylene in ambient air ranged from less than 1 ppb (limit of detection) to 270 ppb.

Concentrations of trichloroethylene in surface water in the vicinity of production and user plants was even more variable ranging from fractions of a ppb to over 5 ppm. Concentrations in soil and sediment ranged from the limits of detection to over 100 ppb but in general were on the order of a few ppb.

1. INTRODUCTION

Trichloroethylene (TCE) is a chlorinated hydrocarbon which is produced in major quantities in the U.S. and is used in a variety of solvent cleaning operations. This compound has a relatively low boiling point; therefore, its emission into the atmosphere probably represents one of the more significant pathways to human exposure. To date, however, very little air monitoring data have been generated to assess potential exposure hazards. In particular, existing data are devoid of measurements in the environment around manufacturing and user facilities where the highest concentrations (and thus the highest exposures) might be expected.

This report describes the sampling rationale, the collection of samples, that is, the sampling protocol, and the analytical methods used to determine the environmental concentrations of trichloroethylene at several sites. The results are presented using maps in conjunction with tabulated data and descriptions of the samples. A separate set of data is presented for each site monitored, and these sets are grouped together under production sites, user sites, and background site.

2. SAMPLING RATIONALE

The objective of this sampling program was to determine levels of trichloroethylene in the environment. To do this, several important factors were considered. Among these were the type of site (production, user, or background); the source of the substance (discharge practices--how the substance is released to the environment); the ecological compartments to be sampled (air, water, soil, sediment, biota); the conditions at the time of sampling (meteorological conditions, plant operation, geography, interfering elements); and statistical requirements. These factors are discussed further under specific environmental compartments in the following section on the sampling protocol.

Sites were selected based on the fact that trichloroethylene is a volatile organic compound and is most likely to reach the environment where it is produced and used. Table 2.1 lists the four major producers of trichloroethylene, a major user site, and a background site.

TABLE 2.1. SITES MONITORED FOR TRICHLOROETHYLENE

Production Sites	
Dow Chemical Company, U.S.A. . .	Freeport, Texas
PPG Industries, Inc.	Lake Charles, Louisiana
Ethyl Corporation	Baton Rouge, Louisiana
Hooker Chemical Corporation . . .	Taft, Louisiana
User Site	
Boeing Company	Seattle, Washington
Background Site	
St. Francis National Forest . . .	Helena, Arkansas

The air sampling effort at each facility was conducted to obtain the following information: (1) the concentration profile around the plant, (2) maximum concentration levels, (3) temporal variations in concentration, and

(4) the variation in concentration as a function of distance downwind from the plant.

Measurements were made in four quadrants surrounding the plant location. The highest concentrations prevailed downwind from the plant location. Therefore, the majority of the sampling and analysis effort was then concentrated in the downwind direction to determine maximum concentrations and temporal and spatial concentration variations.

The air monitoring equipment, a field electron-capture gas chromatograph, used for the trichloroethylene analyses also permitted measurement of methylchloroform, carbon tetrachloride, and perchloroethylene. Therefore, concentrations of these chlorinated hydrocarbons in ambient air were also determined.

In order to detect concentration levels associated with process water discharge, water samples were taken in the receiving stream at the plant outfall and upstream and downstream of the outfall. Samples of aquatic animal tissue, usually fish, were also collected at locations upstream and downstream of plant outfalls. In order to measure the amount present in a normal day's discharge, which may not be accurately represented in grab samples, a 24-hour composite of the effluent was obtained from plant personnel. Water samples were also taken from the naturally occurring surface waters in the immediate area.

In order to determine possible associated levels of trichloroethylene in sediments, samples were taken in close proximity to water sampling sites.

Soil, vegetation, and mammal tissue samples were also taken in the four quadrants surrounding the plant location designated for air sampling. Samples were taken as close to the exact site of the air sampling as possible. The proximity of these samples should yield data suitable for associating levels of trichloroethylene in air with those found in soils.

3. SAMPLING PROTOCOL

Air

Approximately 2 days were devoted to monitoring ambient air levels of trichloroethylene in the vicinity of each producer and user plant. On the first day, measurements were made at several sites (usually 6 to 12) surrounding the plant to obtain a profile of the ambient chlorinated hydrocarbon concentrations and to identify any other emission sources in the vicinity. At least two grab sample measurements were made at each site over approximately a 1-hour period.

For subsequent monitoring, the sampling and analysis van was located at downwind sites and measurements were made over a 20 to 24-hour period to determine temporal and spatial variations and maximum concentration levels. When necessary, the van was moved to attempt to remain centered in the plant plume as well as possible. During this sampling period, grab samples of the ambient air were analyzed at approximately 15 to 30-minute intervals, the sampling rate being limited by the perchloroethylene retention time. Teflon-bag grab samples integrated over a 15-minute collection period were taken at upwind and crosswind sites during the period in which the van was used for downwind measurements. During the 2-day monitoring period at each location, approximately 50 ambient air measurements were performed.

At each site, two ambient air samples were collected on Tenax traps for GC/MS confirmation of the field EC/GC measurement data. The samples were collected over a 1 to 2-hour period coincident with the field measurements.

Meteorological data were collected at each of the sites during the sampling. If a U.S. Weather Bureau Station was located nearby, data were obtained from their records. If not, a MRI Model 1071 portable weather station was set up near the site to make meteorological measurements. The parameters recorded on an hourly basis were wind speed and direction, temperature, barometric pressure, relative humidity, precipitation, and general weather conditions.

During the 2 days at each plant location, water, sediment, soil, and biota samples were taken while personnel in the air sampling van monitored the air for chlorinated hydrocarbons. In addition, a 24-hour composite effluent sample was obtained from plant personnel and samples were prepared for shipment to Battelle's Columbus Laboratories for analyses. Sampling of each medium is described below. The analyses of these samples are described

in subsequent sections, except for biota samples which were not analyzed during the course of this program.

Water

Samples taken by hand were collected approximately 2 to 5 cm below the surface of the water. Care was taken to avoid bubbling as the water entered the bottle. Samples taken with the Teflon-lined vertical sampler were usually taken as close to the surface as possible. In cases where the discharge was expected to stratify in the receiving stream, different depths in the water column were sampled at one location.

All water samples in the receiving stream were taken on the same day in as short a time frame as possible. The request made to the plant personnel for the 24-hour composite effluent sample was made for the day on which the sampling was conducted.

Sample bottles and the sampler were rinsed thoroughly in the water to be collected before the samples were taken. Samples were taken in clear glass bottles sealed with septa and crimped metal caps. At the sites sampled during the initial trip, 12 samples were taken at each sampling location. During the remainder of the program the sample size was reduced to 6 per location; 3 samples were held on wet ice and 3 at ambient temperature. At all locations, 2 additional water samples were taken in 1-ounce amber bottles and frozen on dry ice. Samples of the 24-hour composite and a tap-water sample were similarly prepared.

Sediment

Whenever possible, sediment samples were taken in the same locations at the same time as the water samples. Sediments were collected either by a dredge or by hand. Upon collection, the sediment surface was placed in the bottom of the sample jar. The volume collected approximated a 2-inch soil core. Two samples were collected in glass jars at each site. Sample jars were immediately wrapped in foil and placed in wet ice, then frozen as soon as possible, usually within 8 hours.

Soil

Six 2-inch soil cores were taken in each of the four quadrants around the plant. The corer was washed and rinsed with distilled water and acetone between each location and between each soil type at one location.

To dislodge the sample from the corer, the sampler was inverted over a glass jar. (Soil surface was on the bottom of the jar.) Samples were

immediately wrapped in foil, held on wet ice, and then frozen as soon as possible.

After the initial sampling trip, the sample number was reduced to two per location.

Vegetation

Six 1-ounce-volume vegetation samples were taken at each soil and air sampling site. The vegetation sampled was directly associated with (growing out of) the soil core taken. Samples were coded with subscripts to preserve this correlation. The samples comprised live, whole plants except in cases of large plants, where parts of several were clipped to provide a more representative sample. Samples were collected in amber bottles, placed on wet ice, then frozen as soon as possible. The sample size for any future collections will be reduced to two per location.

Tissue

In the case of both fishes and mammals, specimens were held on wet ice until dissection and/or sample preparation was completed. A minimum of 10 g of muscle tissue comprised each sample. Whenever possible, the tissue was provided by three specimens. For fish, flank muscles were taken; for mammals, muscle was stripped from each of the two hind legs. For both fish and mammals, whole livers were removed. Liver and muscle tissues from the same organisms were coded to preserve possible correlations. In the case of small organisms whose dissection would not provide sufficient sample size, whole bodies were taken.

Dissected tissues were placed in amber bottles; whole bodies were placed in clear glass jars and wrapped in foil. All tissue samples were frozen.

Sample size was dependent upon the availability of the organisms. Six specimens of each species was considered maximum.

Number of Samples

A breakdown of the numbers of samples collected from eight locations monitored November, 1976, through January, 1977, is given below:

Sample Type	Producer	User	Background
Air determinations	354	45	23
Water--clear glass	254	42	12
Water--amber glass	58	14	4
Sediment	38	4	2
Soil	112	8	2
Vegetation	112	8	2
Tissue	79	9	12

Methods were developed for the analyses of air, water, soil, and sediment samples; and these are described in the following section. However, no satisfactory method for the analyses of vegetation and tissue samples could be developed within the time limits of this program. The vegetation and tissue samples are stored in a frozen state for possible future analyses.

4. ANALYTICAL METHODS

Determination of Trichloroethylene in Ambient Air

A method for measurement of trichloroethylene in air has been developed and evaluated. The method involves direct injection of the ambient air into a gas chromatograph (GC) followed by detection of the emerging compounds with an electron-capture detecter (EC).

Equipment and Procedures--A schematic diagram of the system used for on-site field measurements of trichloroethylene is shown in Figure 4.1. Ambient air is continuously drawn through a stainless steel line extending about 4.2 m above the ground and passed through a 5 cc loop attached to a Carle 6-port sampling valve. During sample injection, the carrier flow is diverted through the sampling loop for 15 seconds and the 5 cc air sample is swept onto the GC column. An electronic timer is used to control the injection period and automatically start the integrator at the end of sample injection. The integrator was used primarily to record retention times. The chromatograms obtained from the stripchart recorder were used to quantify the chlorinated hydrocarbon concentrations based on peak height.

Two EC/GC systems were used in the ambient air analysis program. Measurements at Dow, Ethyl Corporation, Hooker Chemical, PPG Industries, and St. Francis National Forest (rural background) were performed with a Varian 1200 EC/GC system. A system using the more sensitive Analog Technology Corporation, Model 140A, EC detector was used for measurements at the Boeing Company plant. The operating conditions and performance characteristics of the two systems are given in Table 4.1.

Primary calibration of the EC/GC systems is discussed in the following section. Secondary calibrations in the field were performed with a standard TCE/nitrogen gas mixture. The sampling system was checked regularly for contamination by injection of the same gas (zero oxygen nitrogen) which was used as the carrier. Very slight, uniform residual background levels equivalent to about 0.1 ppbv of methylchloroform and perchloroethylene were obtained with the more sensitive ATC system. Ambient air measurements made with the system were corrected for these background considerations. Residual backgrounds from trichloroethylene and carbon tetrachloride were not detected.

The gas chromatograph system was operated in Battelle's Columbus Laboratories mobile sampling laboratory. The laboratory is equipped with a 7.6 kw gas-powered generator to provide power for sampling and analysis in any location accessible via a roadway.

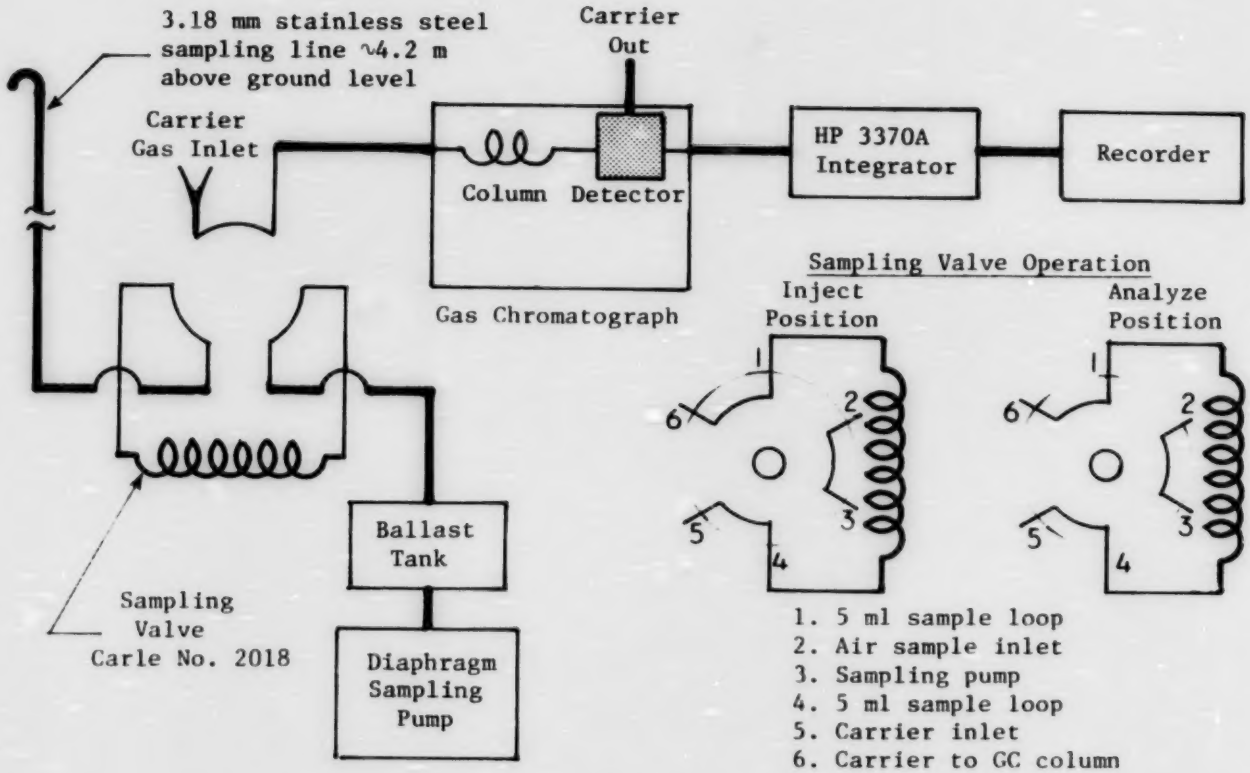


Figure 4.1. Schematic of EC/GC ambient air analysis system.

TABLE 4.1. OPERATING CONDITIONS AND PERFORMANCE CHARACTERISTICS OF THE EC/GC SYSTEMS USED FOR AMBIENT AIR MEASUREMENTS OF CHLORINATED HYDROCARBONS

	Varian 1200	ATC-140A
Column size/material	3.18 mm x 305 cm, stainless steel	3.18 mm x 305 cm, stainless steel
Column material	20% SP-2100/0.1% Carbowax-1500 on 100-120 mesh Supelcoport	20% SP-2100/0.1% Carbowax-1500 on 100-120 mesh Supelcoport
Column temperature	50 C, isothermal	55 C, isothermal
Carrier gas	Matheson nitrogen, oxygen free	Matheson nitrogen, oxygen free
Carrier flow	~35 cc/min	37.5 cc/min
Detector	EC, tritiated titanium	EC, tritiated scandium
Detector temperature	150 C	240 C
Baseline adjustment	NA	275
Read-out	Honeywell 193 recorder, 1.27 cm/min	Honeywell 193 recorder, 1.27 cm/min
Air sample volume	5 cc	5 cc
Injection time	15 sec	15 sec
Typical Retention Times, sec		
Chloroform	326	240
Methylchloroform	424	308
Carbon tetrachloride	498	365
Trichloroethylene	633	[illegible]
Perchloroethylene	1032	[illegible]
Relative Detector Response at 50 ppb, TCE = 1.0		
Methylchloroform	3.9	1.9
Carbon tetrachloride	28.5	8.6
Trichloroethylene	1.0	1.0
Perchloroethylene	4.8	2.0
Estimated Minimum Detection Levels, ppbv		
Methylchloroform	0.3	0.02
Carbon tetrachloride	0.05	<0.01
Trichloroethylene	1.0	0.03
Perchloroethylene	0.3	0.02

In addition to direct injection of ambient air, grab samples were also collected in Teflon bags for GC analysis. A stainless steel diaphragm pump powered by a portable gas-powered generator was used for sample collection. Analysis was performed with the Varian or ATC EC/GC systems by attaching the Teflon bag to the inlet of the sampling loop on the Carle valve.

Gas Chromatograph Calibration--The Varian 1200 EC/GC system was calibrated for measurement of methylchloroform, trichloroethylene, carbon tetrachloride, and perchloroethylene over the concentration range of 1 to 1000 ppbv. The ATC 140A system was calibrated for the four compounds over the concentration range of about 0.1 to 100 ppbv. The calibrations were performed by concurrently injecting the four compounds into the Battelle smog chamber to produce initial concentrations of either 100 or 1000 ppbv. Successive dilutions of the chamber air were made to produce a series lower, known concentrations to complete the calibration curve. The dilution factor for each dilution step was determined independently by following the decrease in concentration of methane injected into the chamber with the chlorinated hydrocarbons. A Beckman Model 109 hydrocarbon analyzer was used for the methane measurements.

In calibrating the Varian GC system, a Matheson 1200 ppbv TCE standard was compared with the chamber concentration of TCE to verify that an initial concentration of 1000 ppbv was obtained.

The calibration curves showing detector response for the Varian and ATC systems are shown in Figures 4.2 and 4.3, respectively. Each point on the calibration curves is the average of two determinations. Agreement between all duplicate determinations was within 5 percent. Both systems exhibit excellent linearity over the concentration range encountered in the field monitoring program.

Field calibrations were performed to verify detector response and retention times using a Matheson gas mixture of 1200 ppbv TCE in nitrogen. Calibrations were performed before, after, and at 6 to 8-hour intervals during the sampling program at each plant.

Determination of Trichloroethylene in Water

The analytical method selected for development is based on sparging the trichloroethylene from the water with an inert gas. These compounds are collected on a trap material and then desorbed onto a gas chromatography column for analysis.

If an inert gas is bubbled through water containing organic compounds which exhibit a low solubility in water, the compounds will be quantitatively partitioned into the gas phase. The enriched gas phase is then passed through a trap that retains the organics but allows the purge gas and most of the water to pass through. A large concentration factor of the volatile

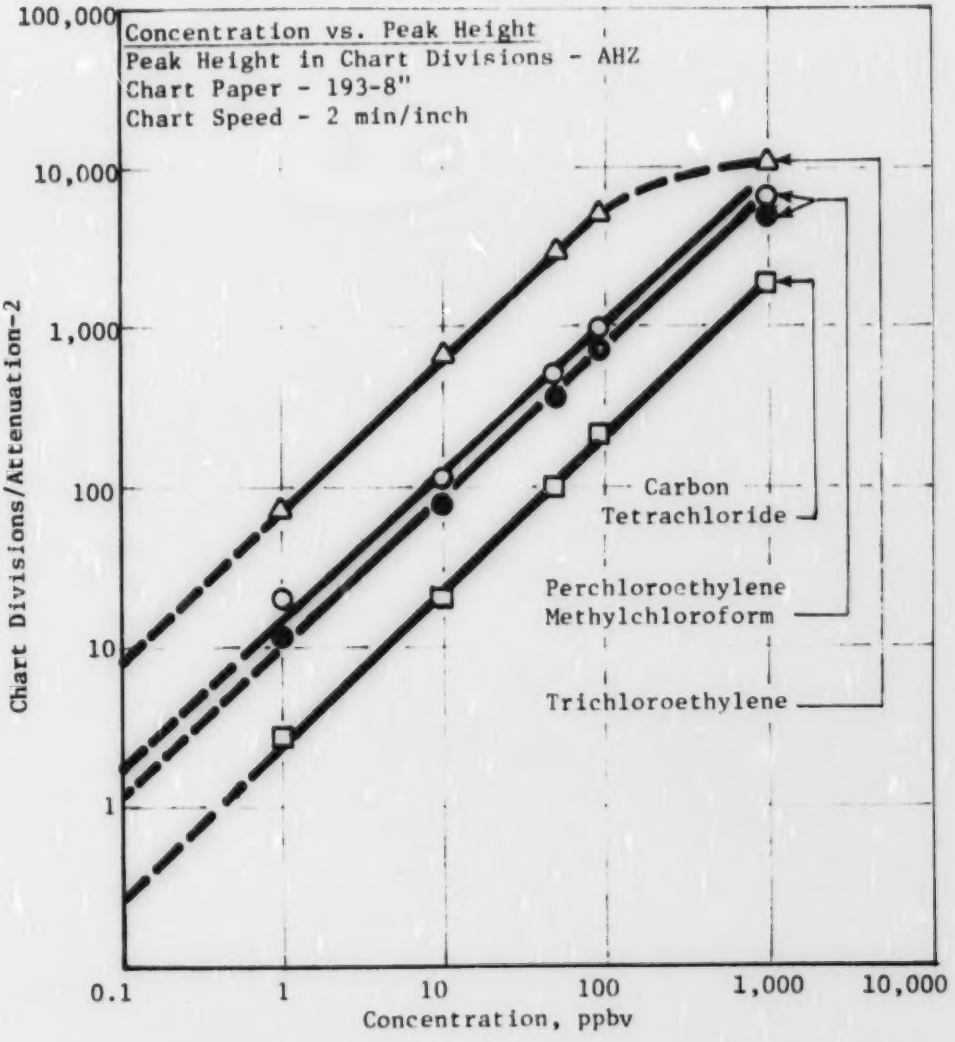


Figure 4.2. Calibration curves for chlorinated hydrocarbons--Varian 1200/EC Detector (Reference: Matheson 1.2 ppm TCE - 36.4 divisions - Attenuation-100).

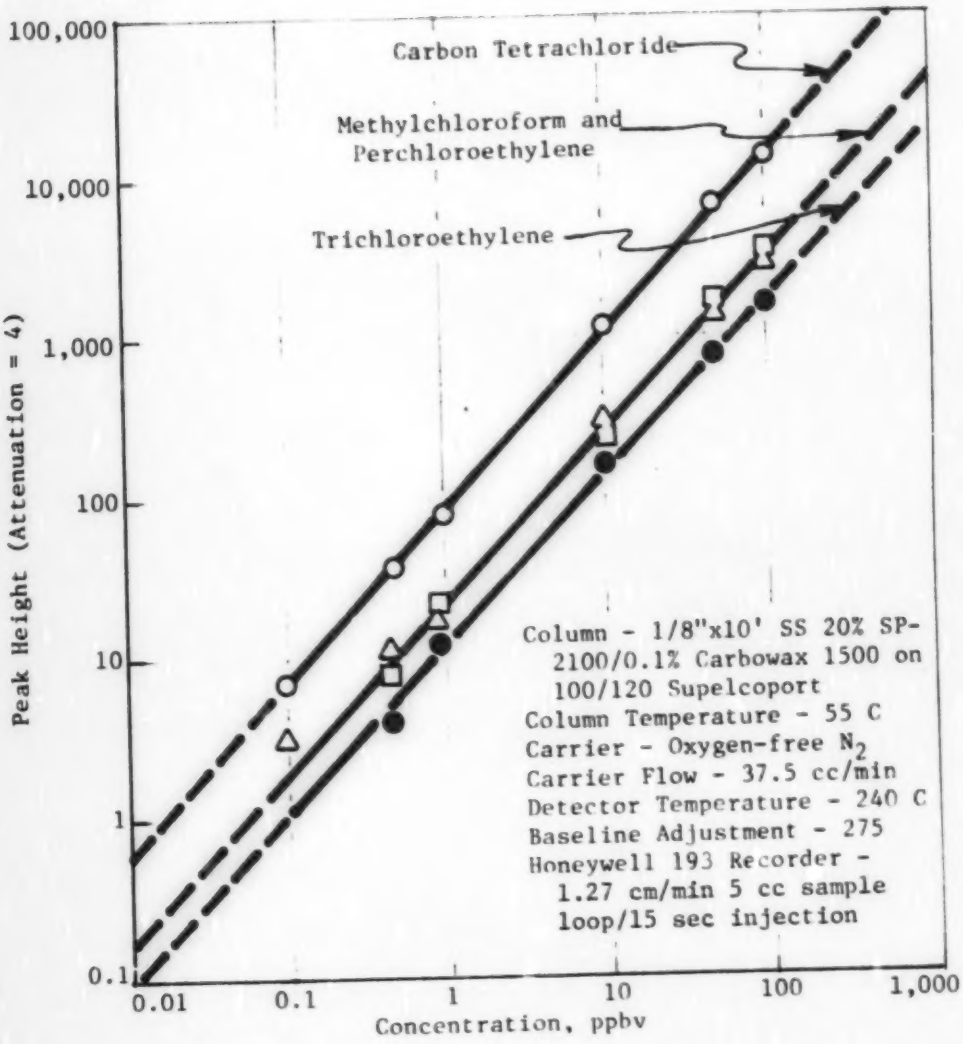


Figure 4.3. Calibration curves for chlorinated hydrocarbons--ATC 140A/EC detector.

organics out of the aqueous phase is accomplished. The trapped organics are then back-flushed onto a gas chromatography column or into a mass spectrometer for analysis.

Instrumentation--A Tekmar Liquid Sample Concentrator, Model LSC-1, was purchased and integrated with a Packard 1700 Series gas chromatography instrument, as shown in Figure 4.4, which shows the purge gas entering the flow meter, the purge-gas-rate control valve, and passing through the water sample sparging tube. The partitioned organics enter the gas phase and are deposited on the collection trap after passing through one path of the 6-way gas control valve. During the water purging cycle, the gas-chromatography carrier gas enters the 6-way control valve at the desorb gas "in" location and passes out of the valve onto the gas chromatography column.

The desorb mode is shown in the lower portion of Figure 4.4, with the 6-way control valve switched so the gas chromatography carrier gas back-flushes the organics onto the gas chromatography column at the same time the trap is heated. The water sample purge gas valve is off during this period and another water sample can be sparged during the analysis of the first sample.

Initial evaluation of this system was not satisfactory because of broadening of the chromatographic peaks. The LSC-1 was modified to replace the resistance heater wrapped around the trap column with direct resistance heating of the stainless steel trap column. A step-down transformer, coupled with a Variac set at 50, heated the trap to 150 C in 8 seconds compared with the 3 minutes required for the original heater. Other modifications included replacing some Teflon lines with stainless steel and heating the transfer line from the LSC-1 to the gas-chromatography instrument.

Column Selection for the Gas Chromatograph--Several column materials were evaluated for the separation of chlorinated organic compounds. The material selected was 20 percent SP-2100 with 0.1 percent Carbowax-1500 on 100 to 120 mesh Supelcoport. Figure 4.5 shows a chromatogram from the vendor literature for 11 chlorinated solvents. The most likely interference with methylchloroform (1,1,1-trichloroethane), peak 5, is 1,2-dichloroethane, peak 4.

The SP-2100 is methyl silicone. The support material is diatomaceous earth which has been acid washed and silane treated. The addition of the 0.1 percent Carbowax is essential for high-quality chromatograms. A standard mixture containing methylchloroform, chloroform, carbon tetrachloride, trichloroethylene, and 1,2-dichloroethane showed the latter compound to be extremely insensitive to the electron-capture detector.

Quantitative Analysis Using the Flame Ionization Detector--The initial quantitative evaluation of this system was done in the 50 to 500-ppb range using a flame ionization detector. A 3-component standard containing methylchloroform, trichloroethylene, and perchloroethylene was prepared in water that had been demineralized and double distilled. A 500 ppb volume per volume in water at ambient temperature and a 50 ppb standard were prepared.

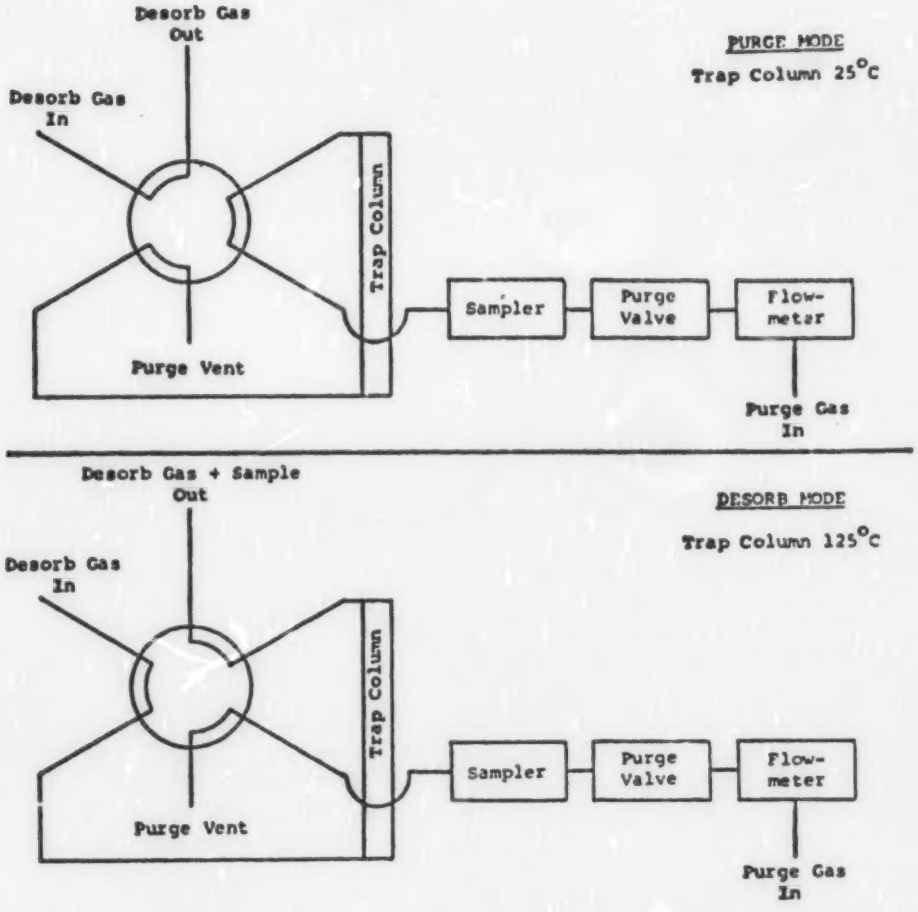


Figure 4.4. Schematic of a liquid sample concentrator.

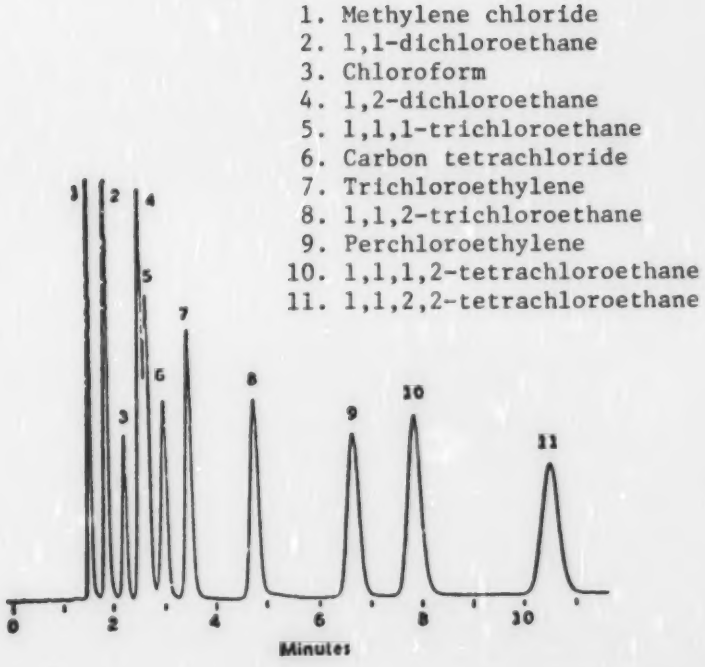


Figure 4.5. Chromatogram of chlorinated solvents.

Instrumental conditions used for analysis of this standard were as follows:

Liquid Sample Concentrator

Sample size - 5 cc standard water solution
Purge gas rate - nitrogen at 40 cc/min for 10 min
Degas temperature - 150 C reached in 10 sec
Trap material - Tenax plus silica gel

Gas Chromatography Conditions

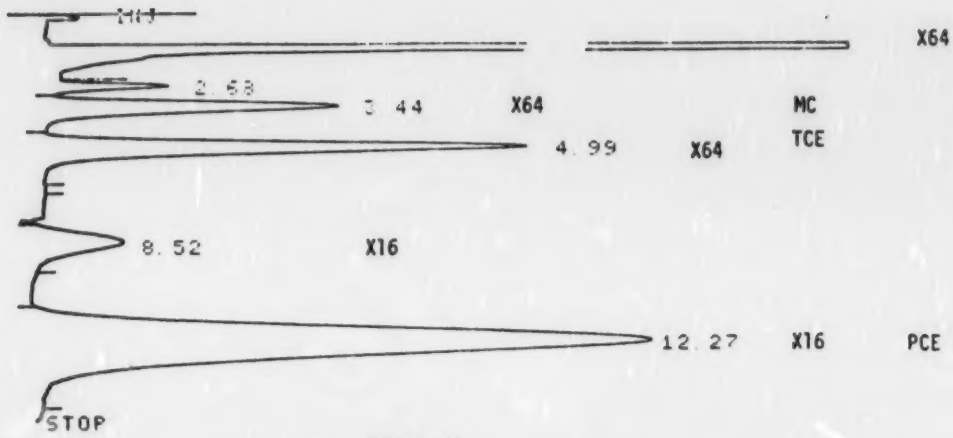
Column - 10 ft x 1/8-in stainless steel packed with 20 percent SP 2100/0.1% Carbowax 1500 on 100 to 120-mesh Supelcoport
Temperatures - Column - 55 C
Detector - 150 C
Injection - 140 C
Gas flows - Nitrogen carrier - 30 ml/min
Hydrogen - 30 ml/min
Air - 300 ml/min
Electrometer - 1 x 10^{-10} amp, 500 volts.

The recording system was a HP 3380A integrator which prints retention time directly above each peak, and then records the total counts for each peak, based on the total area under the peak. The area percentage for each peak recorded in the right-hand column is not significant in this work because it is based on percentage of total area and we do not know the sensitivity factor or the identification of other peaks appearing in the chromatograms.

A reproduction of the actual chromatograms is shown in Figures 4.6 and 4.7. Both chromatograms show some impurities which are caused by the dilution water and/or impurities in the compounds added to the water. The methylchloroform has a retention time of 3.44 to 3.36 minutes and the trichloroethylene 4.99 and 5.01 minutes for Figures 4.6 and 4.7, respectively. The integrator counts representing the area under these peaks were as follows:

Compound	500 ppb	50 ppb
Methylchloroform	624,861	62,092
Trichloroethylene	1,121,598	122,636

The linearity from 50 to 500 ppb using the flame ionization detector is excellent for these two compounds. The degas temperature for the 50 ppb chromatogram did not reach 150 C and this probably explains why the perchloroethylene was not linear. The x values directly above the retention-time values are the attenuation factors used to keep the peaks on scale. Since both compounds were attenuated times 8 and a 5 ml sample was used, it would appear that a sensitivity of about 500 ppt could be reached with a 20-ml sample using the FID detector, provided purer water is used for the standards. The 50 ppb methylchloroform and trichloroethylene represents

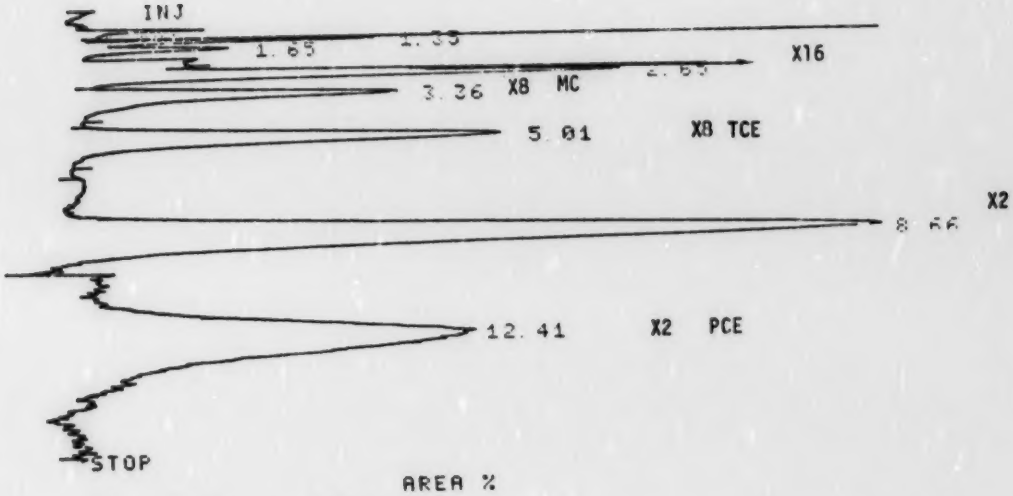


AREA %

RT	TYPE	AREA	
2.68	T	137973	4.824
3.44	TM	624861	21.85
4.99	TM	1121598	39.21
8.52		82084	2.867
12.27		893978	31.25

HP 3380A
DLY 1. STOP 30 REJECT OFF
MV/M 1.00 ATTN 16

Figure 4.6. Chromatogram showing 500 ppb each of methylchloroform (3.44 minutes), trichloroethylene (4.99 minutes), and perchloroethylene (12.27 minutes) using FID detector.



AREA %

RT	TYPE	AREA	
1.35		181478	23.77
1.65	M	139396	18.26
2.65		146389	19.18
3.36	M	62092	8.134
5.01		122636	16.06
8.66		96635	12.66
12.41		14751	1.932

HP 3380A
DLY 1.
MV/M 3.00
STOP 30
ATTN 2
REJECT OFF

Figure 4.7. Chromatogram showing 50 ppb each of methylchloroform (3.36 minutes), trichloroethylene (5.01) minutes), and perchloroethylene (12.41 minutes) using FID detector.

50×10^{-9} ml/ml of water or 68 and 73 ng/ml of water, respectively. Figure 4.8 shows the FID calibration curve.

Quantitative Analysis Using the Electron Capture Detector--The instrumental settings for the liquid-sample concentrator and the gas chromatography were the same as described above except for the detector power source and the air and hydrogen required for the operation of the flame. The electron-capture-detector electrometer settings were 1×10^{-10} A and 25 V.

Preparation of standards required special treatment of the dilution water. All distilled and demineralized water supplies checked contained methylchloroform and trichloroethylene, including a demineralized and double-distilled supply. Untreated well water was lowest in these compounds but had a high iron content; therefore, the well water was not used for dilutions. The integrator counts representing total impurities in the various waters checked are shown in Table 4.2. The Ohio State University demineralized and double-distilled water was sparged with nitrogen while being boiled for 3 hours, which reduced the methylchloroform and trichloroethylene to undetectable amounts; therefore, this water was used to prepare standards.

TABLE 4.2. VOLATILE IMPURITIES IN WATERS

Source of Water	Impurity Counts
City Products Corp., storeroom supply	10,160,000
Tap water, City of Columbus, Ohio	8,910,000
Biology Department, glass still	5,792,000
Deionized water, analytical section	810,000
Ohio State University, double distilled	317,000
Ohio State University, sparged with nitrogen	217,000
Olentangy River, 5th Ave. and King Ave. north of dam	211,000
Ohio State University, boiled and sparged with N_2	15,825
Well water, untreated, Fairfield County	3,203[a]

[a]All values were determined by concentrating 5 ml of water except this well water; 20 ml was concentrated with a total impurity count of 12,812; therefore, one-fourth this amount was reported above.

Standards containing methylchloroform and trichloroethylene at a concentration of 500, 100, and 50 ppt were prepared in the special dilution water using the electron-capture detector. The calibration curves for these

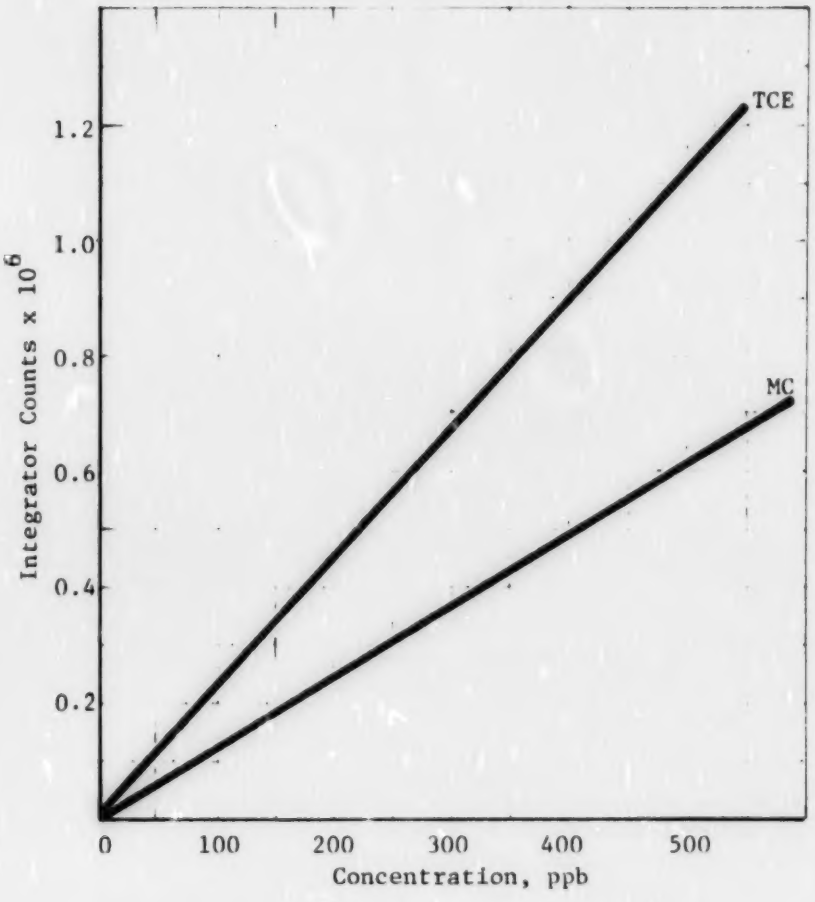


Figure 4.8. Calibration curves for the determination of trichloroethylene and methylchloroform using the FID detector.

runs are shown in Figure 4.9. The sensitivity for methylchloroform is much greater than that for trichloroethylene, which is reversed with the flame ionization detector. The 500 and 100 ppt standards were analyzed by sparging 5 ml of the standard, and the 50 ppt standard was analyzed using 20 ml. The 50 ppt concentration is equivalent to 67.5 pg/ml of water for methylchloroform and 73.3 pg/ml for trichloroethylene.

These calibration curves were not used in the analysis of samples since the HP 3380A integrator is a dedicated computer which retains data input on a standard sample and the amount of a compound per area can be listed for each standard peak in the chromatogram. If the amount per area shows a sudden change under the same operating conditions, this would indicate operation beyond the linearity range of the detector, a poor standard or that some other instrument trouble exists. A sample run is automatically computed from the standardization data retained by the computer. A multiplication factor to adjust for sample size or amount of dilution can be added to the stored data at the time each sample is injected. The electron-capture detector was used for all sample analyses with a maximum standard concentration of 50 ppb. If the first run on a sample indicated that the concentration was much higher than 50 ppb, the sample was diluted to bring it into range or minor adjustment was made by reducing the quantity of sample. A 5-ppb standard was generally used for low concentrations and up to 20 ml of sample.

The initial objective was to obtain chlorinated hydrocarbons through perchloroethylene without use of our program temperature facilities; however, as shown in Figure 4.6, the resolution would not be adequate to elute perchloroethylene in 13 minutes with methylchloroform, carbon tetrachloride, and other possible impurities in industrial waters. The flow and temperature were reduced slightly to provide a retention time of about 13 minutes for trichloroethylene as shown in Figure 4.10. The relative concentrations of carbon tetrachloride in the samples were not as high as shown in Figure 4.10; therefore, many samples were analyzed with the trichloroethylene retention time set at 10 minutes.

Preparation of Standards--Standards are prepared from the specially prepared water described earlier. A 1-liter volumetric flask is filled with the special water and a hypodermic syringe is used to inject a known quantity of the compounds. The flasks are placed on a shaker for 16 hours (overnight) and this forms the base standards which are diluted to lower concentrations. Base standards containing 5 µg/ℓ of water (5 ppm) and 2 µg/ℓ of water have been rediluted and analyzed on the electron-capture detector. Good agreement was obtained that would indicate that the measurements of these small quantities were reproducible and also that these quantities were completely soluble in 1 liter of water. The base standards and diluted standards were protected from light at all times. The base standards were used for 2 to 3 weeks before any concentration deterioration was noted, but the diluted standards were made fresh daily.

Precision and Accuracy--The precision of the method was tested using 10 determinations of a standard containing 50 ppb by volume of both

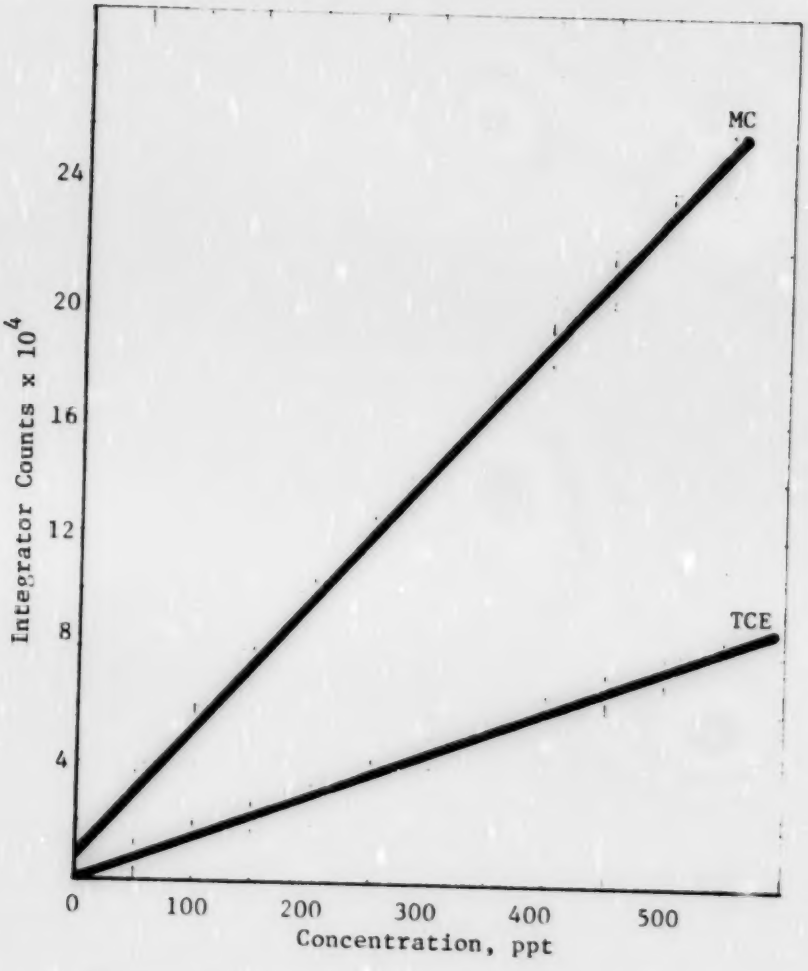
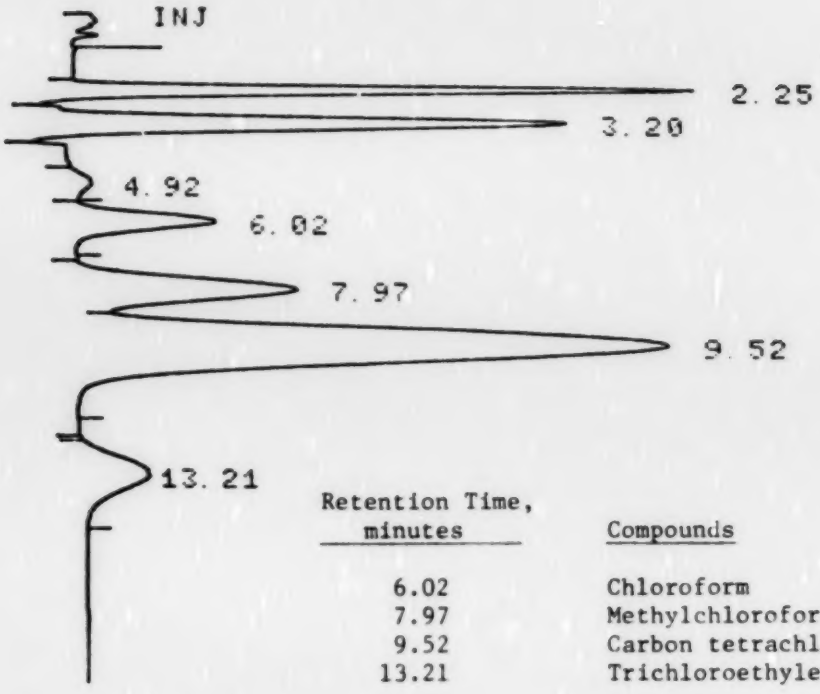


Figure 4.9. Calibration curves for the determination of trichloroethylene and methylchloroform using the electron capture detector.



Retention Time, minutes	Compounds
6.02	Chloroform
7.97	Methylchloroform
9.52	Carbon tetrachloride
13.21	Trichloroethylene

Figure 4.10. Chromatogram of several chlorinated hydrocarbons using the electron-capture detector after completion of development work.

methylchloroform and trichloroethylene. The following precision data were obtained:

	Methylchloroform	Trichloroethylene
Average	49.75	50.29
Sigma (σ)	1.65	1.68
Coefficient of variation	3.3	3.4

Five of the above analyses were made on different standards and the other five on the same standard. Two different operators were involved.

Since no primary standards exist for this type work or no cross-laboratory analyses among several laboratories have been performed to our knowledge, the absolute accuracy is not known.

Water Sample Data to be Presented--In addition to the concentration of trichloroethylene and methylchloroform in each sample, the following information is given:

(1) Date sampled

(2) Data analyzed

(3) Amount of sediment in the sample

(4) Sparging characteristics

(5) Rough quantitative values for chloroform and carbon tetrachloride

(6) Comments which indicate which samples are composites, tap waters, or required unusually high sample dilutions, and other miscellaneous remarks.

The sediment in the samples was classified as C=clear, L=light, M=medium, and H=heavy. The sediment concentrations were judged before shaking the samples prior to analysis. If no particles had settled on the bottom, they were classified as clear; any observable particles on the bottom were noted as light; if the bottom was nearly covered, it was classified as medium; and if the bottom was entirely covered, this was considered heavy. The samples classified as heavy contained only a very thin coating on the bottom. Some of these sediments appeared to be a gelatin-like substance.

The column headed "sparging foam" indicates the degree of foam generated while sparging the compounds from the water samples. These are designated as ND=none detected, L=light, M=medium, and H=heavy. Blank areas indicate that we made no observation. None of the samples produced

sufficient foam to cause trouble with carry-over to the collection trap; however, many of the samples were diluted before analysis, which would reduce foaming.

The results reported for chloroform and carbon tetrachloride were obtained by analyzing a standard mixture containing these two compounds plus the methylchloroform and trichloroethylene. Sensitivity ratios were calculated based on trichloroethylene as 1 and this permitted a rough quantitative estimation of these compounds.

Determination of Trichloroethylene in Soil and Sediment

Trichloroethylene is expected to be present in soil and sediment samples at levels of the order of 10^{-1} to 10^{3} ppb by weight. The analysis technique must, therefore, be capable of detecting 10^{-1} to 10^{-2} ng of each substance in reasonably sized samples of 0.1 to 1.0 g. Furthermore, a high level of specificity is required to avoid interferences from the many other organic substances commonly present in soil and sediment samples.

Electron-capture gas chromatography (EC/GC) is ideally suited to detection of these volatile chlorinated hydrocarbons because of its very specific response to electrophilic substances at the required concentration levels. However, before EC/GC can be applied to such samples, the trichloroethylene and methylchloroform must be extracted to a phase suitable for injection into the chromatograph. Either gaseous or liquid samples can be handled by the chromatograph. The three methods used for these types of samples therefore involve a preliminary conversion of the trichloroethylene sorbates to either gaseous or solution forms.

Extraction Methods--Basically three different methods for trichloroethylene extraction have been considered:

(1) Thermal desorption--A sample of soil is heated while being purged by a stream of nitrogen. The eluted trichloroethylene is trapped on Tenax or other suitable sorbents and then injected into the chromatograph by flash heating of the trap.

(2) Liquid extraction--The trichloroethylene is solvent extracted using acetone and/or hexane. The resulting solution can then be injected directly into the chromatograph.

(3) Aqueous sparging--Inasmuch as trichloroethylene has low solubility in water, this substance can be used to disperse soil and sediment samples to render them susceptible to purging by nitrogen. The effluent trichloroethylene is then handled much the same as with the thermal desorption method.

Method (1) has been shown to be useful for analysis of trichloroethylene and certain other chlorinated hydrocarbons in dry or only slightly wet samples. However, the excessive amounts of water likely to be present with sediment samples render this approach difficult at best. Furthermore, it has been shown that certain chlorinated hydrocarbons, such as chloroform and methylchloroform, are not recovered efficiently by this method. Indeed, results with some model soils suggest that methylchloroform is chemisorbed and can be recovered only as vinylidene chloride by this method.

Method (2) is efficient and satisfactory providing care is taken to minimize sample losses during the extraction and subsequent concentration steps of the procedure. (If aliquots of solution are analyzed, the sensitivity of the method is reduced.)

Method (3) also suffers from poor recovery of methylchloroform that is chemisorbed in the soil surface. However, this procedure more closely imitates the probable mechanism for mobilization of methylchloroform and trichloroethylene in the environment. Furthermore, Method (3) is an "on-line" procedure with little or no chance for either losses or gains of methylchloroform and trichloroethylene due to exposure of the sample to laboratory air. The method is equally applicable to wet and dry samples. The results of its application reflect the availability of methylchloroform and trichloroethylene to the environment rather than total methylchloroform and trichloroethylene exposure.

Apparatus--A schematic representation of the apparatus used for sparging of soil samples is shown in Figure 4.11. In use, presparged water (3 to 4 cc) is loaded into the fritted glass vessel, the soil sample injector is mounted, and the sparger is attached to the sample trap valve. The sample side of the system is then flushed with zero nitrogen until a suitable blank reading for methylchloroform and trichloroethylene is obtained. Usually, this is possible within about 10 minutes or less; but flushing is continued for approximately the 30 minutes required for the blank analysis. The soil sample is then injected into the water and the effluent trichloroethylene and methylchloroform are trapped on Tenax maintained at room temperature. During sparging of the soil-water mixture, the sample is agitated by immersion in an ultrasonic bath. This serves to rapidly disperse the soil and facilitate sparging. Sparging periods of 10 minutes at 30 to 40 cc/min are sufficient. Following the sparging period, the by-pass around the sparger is opened to permit flushing of the water vapor from the Tenax trap. A flushing period of 5 to 6 minutes is sufficient to remove the water vapor without removing trichloroethylene or methylchloroform from the Tenax. The trap valve is then switched to permit flushing by the zero-nitrogen GC carrier gas and the trap is heated rapidly (at ~500 C/min) to 190 C to inject the methylchloroform and trichloroethylene into the chromatograph.

The soil or sediment injector is constructed as a syringe-like device with its open end capped by a tight-fitting Teflon plug. The injector is weighed and then used to core the analysis sample directly from the bulk as-received sample. Reweighing and capping of the injector are done rapidly to minimize contact with the laboratory air. The injector is then kept closed

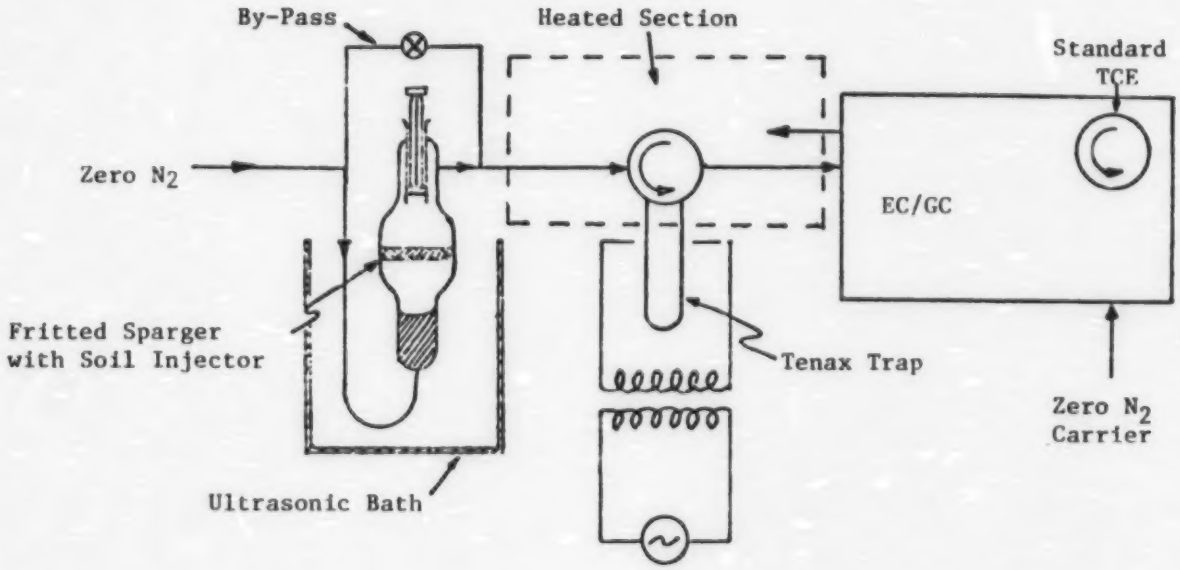


Figure 4.11. Schematic of soil and sediment analysis apparatus.

until injection of the soil into the sparger, at which time both the soil and Teflon plug are manually ejected.

The chromatograph is a Varian 1200 equipped with a Ti(H^3) detector. The column is a 1/8-inch by 10-foot stainless steel column packed with SP-2100 (GP 20 percent SP-2100/1 percent Carbowax-1500 on 100-120 mesh Supelcoport). Output signals are quantified using an Infotronics Model CRS 204 integrator coupled to a TTY output.

Standardization is accomplished using a precalibrated gas standard of TCE in nitrogen. Approximately 4-ng samples of trichloroethylene are usually used for standardization. Such samples yield peak areas on the order of 10^4 μv/sec, and peaks on the order of 10^2 to 10^3 μv/sec can be separated from the inherent background noise. Comparative calibrations with methylchloroform and trichloroethylene indicate a relative response of 3.36 for MC/TCE at equal concentrations. The response curve of the detector is not perfectly linear but rather varies with $C^{1.05}$ in the concentration range of interest. A sample chromatogram showing response obtained with one sediment sample is shown in Figure 4.12.

Quality of Results--There are several points that must be recognized in discussion of the significance of the results of trichloroethylene and methylchloroform analyses on soil and sediment samples. Ideally, standardization should be performed using well-characterized standards of trichloroethylene and methylchloroform on substrates that closely simulate those of subject samples, and these standards should be traceable to primary standards established by independently certified means. Such standards are not available for methylchloroform and trichloroethylene in soils and sediments, nor is it possible to reliably prepare such standards because of the inherent instability of this type of specimen. Because of the general stability of trichloroethylene in a nonoxidizing atmosphere, we have chosen to use trichloroethylene in nitrogen as the reference standard for the current work. Analysis of the standard was made by the manufacturer and has been cross-checked with samples of the same concentration prepared by injection of liquid samples into the Battelle smog chamber. The standard being used appears to be accurate to within a few percent.

A second infringement on the quality of the results is related to the basic heterogeneity of the samples. Any soil sample is likely to be a composite of various organic and inorganic structures, e.g., sand particles, clays, organic residues, plant fragments, etc. Such local heterogeneity is likely to be reflected in appreciable local gradients in the distribution of methylchloroform and trichloroethylene. These local-gradient tendencies are likely to be superimposed on the natural vertical and horizontal gradients that are caused by temporal and spatial variation in the flux of methylchloroform or trichloroethylene to a given sample area. Because of the limited size of the analytical sample, the results must therefore be considered as point analyses rather than as representative analyses. This situation is magnified further with the sediment samples. With sediments, the fraction of the sample that is present as a liquid phase is much larger than with the soil samples. Results can vary considerably thereby reflecting the partitioning of methylchloroform and trichloroethylene between the solid and liquid phases.

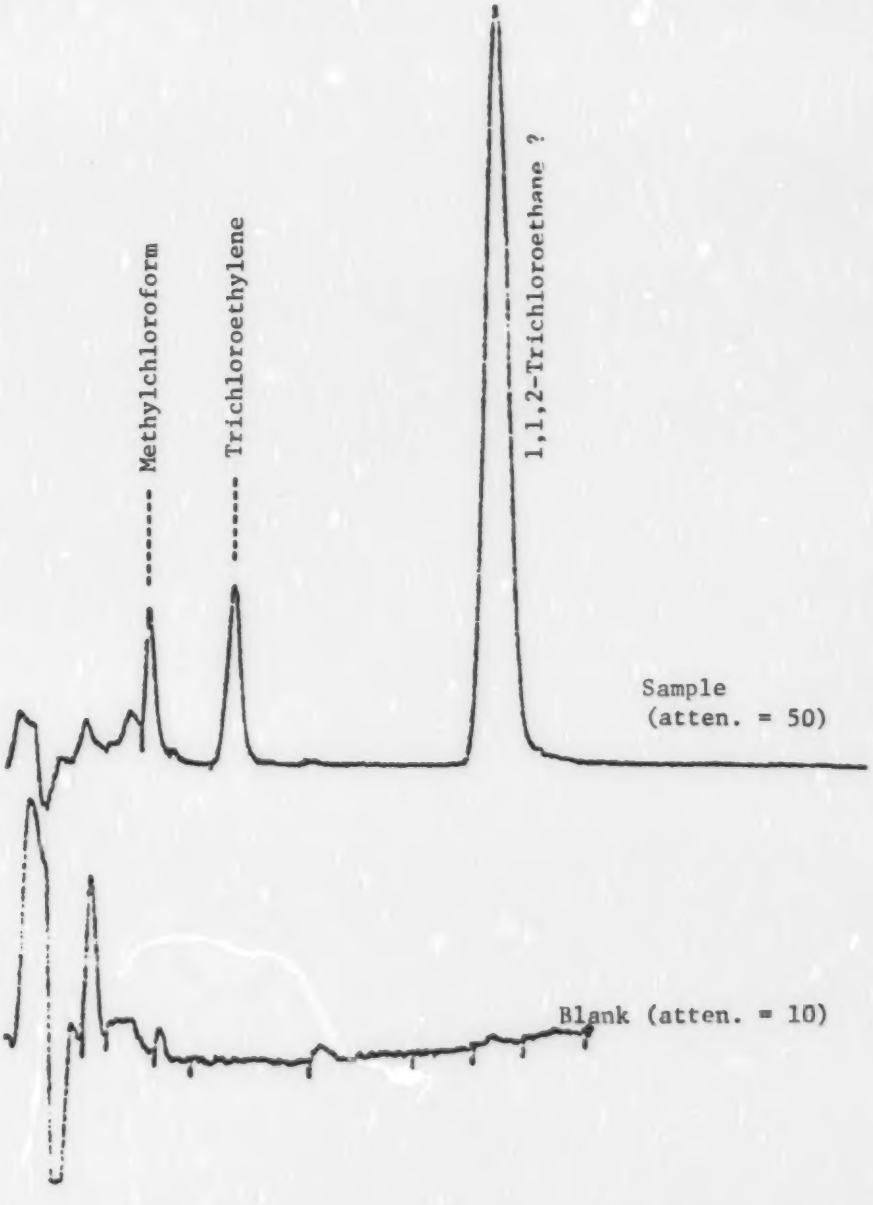


Figure 4.12. Sample chromatogram for sediment.

5. MONITORING DATA

The sampling rationale, sampling protocol, and analytical methods have been described. The results are presented as a series of maps and tables which describe the locations, the nature of the samples, and the concentration of trichloroethylene in the samples. A separate set of data is presented for each site.

Production Sites Monitored

For each trichloroethylene production site, a map is presented with sampling points indicated (Figures 5.1 to 5.4). The results from the analysis of the samples and detailed descriptions of the sampling locations are presented (Tables 5.1 to 5.12).

User Site Monitored

The data obtained at a trichloroethylene user site is presented in Figure 5.5 and Tables 5.13 to 5.14.

Background Site Monitored

The data obtained at St. Francis National Forest near Helena, Arkansas, are presented in Tables 5.15 to 5.17. This site represents a rural background site and is removed from known sources of trichloroethylene and major industrial activity (see Figure 5.6).

Discussion of Results

The ambient air concentration profiles around all facilities monitored are characterized by increased concentrations of trichloroethylene in the downwind direction from the source. Upwind measurements, which showed significantly lower trichloroethylene concentrations, do not give any evidence of other trichloroethylene sources which would contribute to the observed downwind levels.

Considerable variation was observed in the maximum downwind levels of trichloroethylene at the various production plants. Maximum concentrations ranged from 11 to 270 ppbv at the trichloroethylene production facilities. The variations in the observed maximum concentrations among plants may be due to differences in (1) production processes, (2) emission control equipment, (3) meteorological conditions, and (4) distance from plant. Higher production capacity apparently does not necessarily imply higher emissions since the maximum concentrations observed at the larger plants were lower than those observed at the smaller operations.

Very large temporal variations were generally observed at a given site downwind from the trichloroethylene production facilities. Changes in meteorological conditions (wind speed and direction) and/or variations in the process emissions may account for this phenomenon.

Duplicate analyses on some of the soil samples suggest that sample heterogeneity may contribute 0 to 50 percent deviation in the reported values for individual analyses. It is interesting to note that both soil and sediment samples from the background site display trichloroethylene content equal to or greater than many of the plant-site samples. However, if it is assumed that a true average background level can be obtained by averaging all results equal to or less than the background-site levels, there still remains a number of samples containing significantly more trichloroethylene than background.

The highest levels of trichloroethylene are associated with sediment samples. Chromatograms of these high-concentration-level samples also show the presence of appreciable quantities of other EC-sensitive compounds. For example, the same chromatogram shown in Figure 4.12 indicates the presence of other chlorinated hydrocarbons including a relatively large amount of what is believed to be 1,1,2-trichloroethane. A peak believed to be due to perchloroethylene was present in some chromatograms and small amounts of carbon tetrachloride were detected in some of the samples. Other peaks were sometimes present but none of these interfered with the trichloroethylene analyses.

Although the results for the sediment samples generally reflect average concentrations of trichloroethylene present in both the liquid and solid phases of the samples, with two samples, F-1-S and F-3-S, an attempt was made to distinguish between the two phases. In these experiments, a portion of each sample was centrifuged to permit sampling of the liquid phase. Analyses of the resulting water samples differed considerably from the bulk sample analyses. In both cases, the methylchloroform concentration was approximately the same as in the bulk sample.

However, the trichloroethylene content of the water was nearly an order of magnitude smaller in the water than in the bulk sample. While these experiments are not conclusive, they suggest that the trichloroethylene was truly associated with the solid phase and that the observed methylchloroform was primarily associated with the liquid phase. In other words, if there is any methylchloroform absorbed on the solid phase of these samples, it is present in a form that is not readily mobilized.

MONITORING DATA

PRODUCTION SITE 1

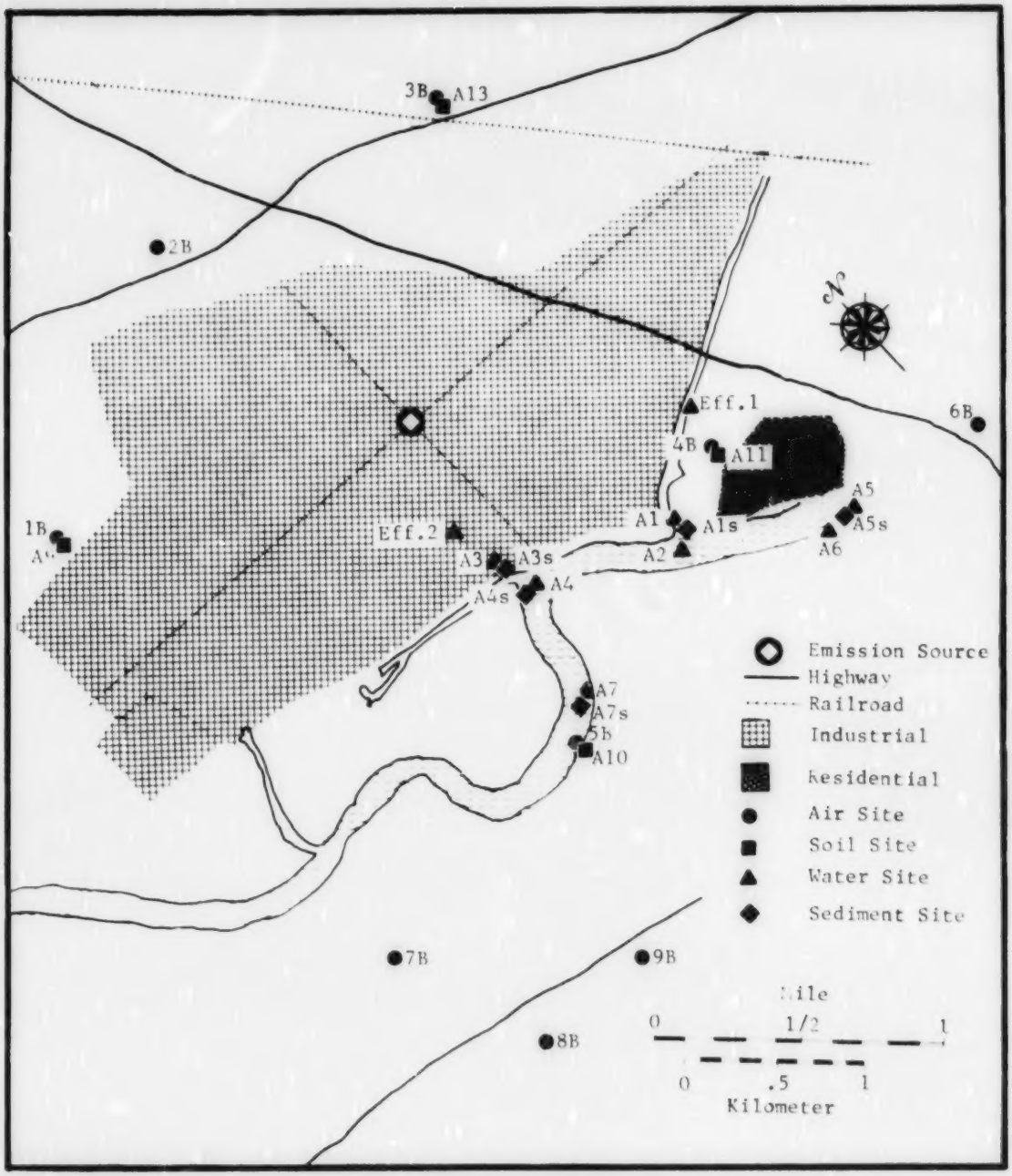


Figure 5.1. Sampling locations at Dow Chemical Plant B, Freeport, Texas--trichloroethylene production site.

TABLE 5.1. AMBIENT AIR MEASUREMENTS AT DOW CHEMICAL PLANT B (TRICHLOROETHYLENE PRODUCER)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b]				Wind Speed, m/s	Meteorological Observations[c]			
					MC	CCl_4	TCE	PCE		Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
1B	1.9	290	11/11	0945	≤0.3	0.15	≤1	≤0.3	4-8	180	23	ND[d]	760
				1000	"	"	"	"	"	"	"	"	"
2B	1.4	350	11/11	1030	0.5	"	"	"	5-9	175	25	"	"
				1100	0.7	0.30	"	"	"	"	"	"	"
				1735	3.8	0.36	"	"	2	"	24	"	759
				1813	0.6	0.33	"	"	"	"	"	"	"
				1833	0.7	0.27	"	"	"	"	"	"	"
				2255	≤0.3	0.24	"	"	5-11	335	22	"	760
			11/12	1046	"	0.14	"	"	7-13	025	11	"	769
3B	1.8	060	11/11	1135	0.7	0.53	"	"	5-10	185	26	"	759
				1205	4.6	0.14	"	"	"	"	"	"	"
			11/12	1125	≤0.3	0.15	"	"	7-13	025	11	"	765
4B	2.4	145	11/11	1325	"	0.12	"	"	5-9	200	26	"	759
				1405	"	0.15	"	"	"	"	"	"	"
			11/12	1335	"	0.20	"	"	5-11	025	10	"	768
5B	2.4	195	11/11	1435	"	0.15	"	"	5-8	205	26	"	759
				1505	"	0.14	"	"	"	"	"	"	"
				2340	"	0.56	7.2	2.1	6-13	025	16	"	762
			11/12	0010	"	0.82	2.0	≤0.3	"	"	"	"	"
				0040	"	0.36	1.4	0.5	5-10	015	13	"	"
				0140	"	0.29	2.6	1.0	5-12	005	12	"	763
				0210	"	0.33	2.7	0.7	"	"	"	"	"
				0240	"	0.27	5.0	≤0.3	6-12	020	11	"	"
				0310	"	0.19	1.7	"	"	"	"	"	"
				0340	"	"	≤1	"	5-10	015	"	"	764
				0410	"	0.43	11.5	0.9	"	"	"	"	"
				0440	"	0.22	≤1	≤0.3	6-10	025	10	"	765
				0510	"	0.15	"	"	"	"	"	"	"
				0540	"	0.24	"	"	5-12	"	11	"	766
				0610	"	0.30	"	"	"	"	"	"	"

TABLE 5.1. (Continued)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
5B	2.4	195	11/12	0640	≤0.3	0.20	≤1	≤0.3	6-10	020	11	ND	767
				0710	"	"	"	"	"	"	"	"	"
				0740	"	0.23	"	"	5-13	025	"	"	"
				0810	"	0.22	"	"	"	"	"	"	"
				0840	"	0.20	"	"	"	"	10	"	768
				0910	"	0.64	"	"	"	"	"	"	"
				0940	"	0.19	"	"	5-10	015	11	"	769
				1010	"	0.37	11.0	"	"	"	"	"	"
				1045	"	1.0	2.0	"	7-13	025	"	"	"
				1115	"	0.43	≤1	"	"	"	"	"	"
				1145	"	0.20	"	"	5-10	"	"	"	768
				1700	"	0.54	"	"	"	"	9	"	"
				1733	"	1.4	"	"	"	"	"	"	767
6B	3.4	140	11/11	1550	"	0.15	"	"	5-8	195	26	"	759
				1625	"	0.13		"	"	"	"	"	"
7B	3.1	225	11/12	1323	"	2.1	"	2.6	5-11	025	10	"	768
				1355	"	0.84	"	0.5	"	"	"	"	"
8B	4.4	210	11/12	1455	"	2.4	3.0	3.4	"	"	9	"	767
				1525	"	1.0	≤1	1.2	"	"	"	"	"
				1555	"	1.4	4.4	2.8	5-8	"	"	"	"
9B	3.5	200	11/12	1620	"	0.18	≤1	≤0.3	5-9	"	"	"	"

[a]North - 360°.

[b]To convert to $\mu g/m^3$ multiply ppbv by MC - 5.46; CCl_4 - 6.29; TCE - 5.37; PCE - 6.78.

[c]General weather conditions: 11/11/76 Cloudy in morning, clearing in afternoon. Trace of rain 0800-0900 hrs and around 2300 hrs. Rapid change in wind speed/direction and temperature at about 2000 hrs.
11/12/76 Heavy overcast of clouds, no sunshine. No precipitation.

[d]ND = not determined.

TABLE 5.2. ANALYSIS OF WATER, SOIL, AND SEDIMENT SAMPLES FROM DOW CHEMICAL PLANT B (TRICHLOROETHYLENE PRODUCER)[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Water					
A-3	11/9/76	11/29/76	Heavy	Light	20	172	12	19	Surface
A-4	11/9/76	11/30/76	Medium	Light	23	197	9	3	Bottom
A-5	11/9/76	11/23/76	Heavy	Light	0.8	5	1	5	Surface
A-6	11/9/76	11/23/76	Heavy	Light	1	13	3	7	Bottom
A-7	11/9/76	11/17/76	Heavy	ND	0.1	0.9	1	0.3	Surface
A-9	11/13/76	11/30/76	Clear	ND	17	19	<0.1	<0.1	Tap water
No. 2	11/12/76	12/1/76	Light	Medium	8	272	14	3	Composite

Soil

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
A-9	0.215	28.8	<0.07	<0.06
A-10	0.488	15.9	0.038	0.11
A-11	0.203	31.4	3.4	<0.07
A-13	0.193	21.7	1.6	0.45

Sediment

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
A-3-S	0.275	34.8	0.44	0.15
A-5-S	0.240	46.8	0.34	ND[c]
A-4-S	0.566	27.8	0.24	0.21
A-7-S	0.244	49.0	0.31	0.036

[a] Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b] Dry basis, ppb by weight.

[c] Practical detection limits: MC = 6 pg: TCE = 10 pg.

TABLE 5.3. DESCRIPTIONS OF SAMPLING LOCATIONS AT DOW CHEMICAL PLANT B, FREEPORT, TEXAS (NOVEMBER 9-12, 1976)

Water

A3 - Surface sample, mouth of Plant B effluent canal to Brazos River; 20 m wide, 6 m deep; swift current, some turbulence; turbid.

A4 - Bottom sample, same location as A3 taken 4 m deep.

A5 - Surface sample 400 m downstream of plant outfall in Brazos River; taken in center of channel; 30 m wide, 5 to 6 m deep; swift current; turbid.

A6 - Bottom sample, same location as A5 taken 4 m deep.

A7 - Surface sample, 800 m upstream from plant outfall in Brazos River; 30 m wide, 5 to 6 m deep; steep banks bounded by recreational areas; swift current; turbid.

A9 - Tap water from Lake Jackson Holiday Inn, Freeport, Texas.

EFF2 - 24-Hour composite effluent sample collected November 11-12, 1976.

Sediment

A3S - Mouth of Plant B effluent canal taken on right bank (inorganic effluent component enters on this side of channel; black, compact silt/gumbo).

A4S - Mouth of Plant B effluent canal taken on left bank (organic effluent component erter on this side of channel); black, compact silt/sand/gumbo.

A5S - 400 m downstream of plant outfall in Brazos River; fine-textured, dark loam.

A7S - 800 m upsteam from plant outfall in Brazos River; brown, fine-textured silt/clay.

Soil

A9 - Open field at Dow gate B-38; corresponds to air sampling site 1B; periodic heavy traffic in area; root-bound compact humus.

A10 - Top of bank of Brazos River on edge of golf course; corresponds to air sampling site 5B; light residential traffic within 400 m; sandy layer over humus/clay.

A11 - Open lot at intersection of minor city streets; corresponds to air sampling site 4B; light commercial and residential traffic in area; root-bound humus.

A13 - Open lot adjacent to Eagles parking lot off Route 332; corresponds to air sampling site 3B; moderate traffic flow within 200 m; compact, root-bound humus.

MONITORING DATA

PRODUCTION SITE 2

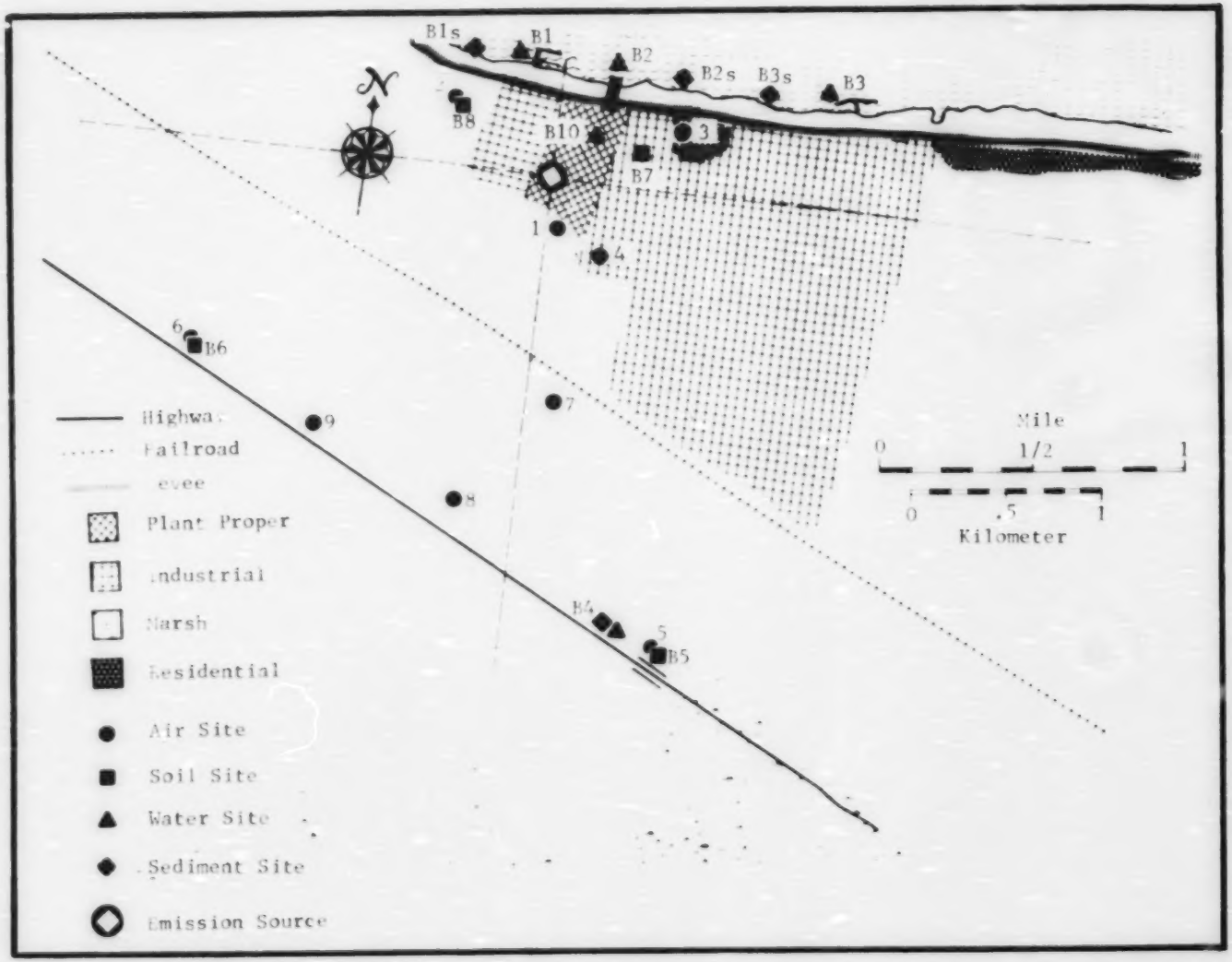


Figure 5.2. Sampling locations at Hooker Chemical, Hahnville, Louisiana--trichloroethylene production site.

TABLE 5.4. AMBIENT AIR MEASUREMENTS AT HOOKER CHEMICAL (TRICHLOROETHYLENE PRODUCER)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
1	0.2	155	11/15	0930	≤0.3	2.3	21	1.0	5	360	12	ND[d]	759
				1035	"	3.0	140	23	"	"	"	"	"
				1105	"	0.43	26	5.2	"	"	"	"	"
				1135	"	1.9	140	38	"	"	"	"	"
2	0.6	315	11/15	1305	"	0.15	≤1	0.8	"	"	"	"	"
				1337	"	0.11	"	≤0.3	"	"	"	"	"
			11/16	1605	"	0.15	"	"	4	020	9	"	763
3	0.8	055	11/15	1435	"	"	5.4	"	"	030	12	"	759
				1505	"	0.13	≤1	"	"	"	"	"	"
			11/16	1419	"	"	"	"	5	020	9	"	762
4	0.5	145	11/15	1728	"	"	3.4	47	4	030	11	"	760
				1755	"	0.16	≤1	4.7	"	"	"	"	"
				1825	"	0.14	"	≤0.3	3	020	"	"	"
				1855	"	0.15	"	15	"	"	"	"	"
				1925	"	"	"	7.6	2	010	10	"	761
				1955	"	0.14	"	≤0.3	"	"	"	"	"
				2025	"	0.13	1.8	"	"	"	"	"	"
				2055	"	"	≤1	25	"	"	"	"	"
				2125	"	0.14	"	≤0.3	5	360	9	"	"
				2155	"	0.15	"	"	"	"	"	"	"
				2235	"	0.16	"	"	"	"	"	"	"
			11/16	0425	"	4.6	270	40	4	"	8	"	"
				0450	"	0.15	≤1	≤0.3	"	010	"	"	"
				0517	"	"	"	"	"	"	"	"	"
				0548	"	0.16	"	"	"	"	"	"	762
				0617	"	0.13	"	"	"	"	"	"	"
				0647	"	"	"	"	3	360	"	"	"
				0715	"	0.12	"	"	"	"	"	"	"
				0745	"	0.15	"	"	4	"	"	"	763

TABLE 5.4. (Continued)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
5	2.7	160	11/15	1630	≤0.3	0.23	≤1	0.6	4	010	10	ND[d]	760
				1700	"	0.15	"	0.5	"	"	"	"	"
			11/15	1600	"	0.18	"	≤0.3	"	020	9	"	763
6	2.2	235	11/15	1530	"	0.15	"	"	5	350	10	"	759
				1600	"	0.1[illegible]	"	"	"	"	"	"	"
7	1.1	175	11/15	2305	"	0.18	"	"	"	010	9	"	761
				2335	"	0.13	"	"	"	"	"	"	"
8	1.8	190	11/16	0025	"	--	1.6	"	2	"	8	"	"
				0055	"	0.15	≤1	"	"	"	"	"	"
				0125	"	0.64	6.0	2.0	4	360	9	"	"
				0155	"	0.54	2.6	0.5	"	"	"	"	"
				0225	"	0.52	2.1	0.7	"	"	8	"	"
				0255	"	0.18	≤1	≤0.3	5	"	"	"	"
				0325	"	0.36	"	"	"	"	9	"	"
				0830	"	0.60	3.4	1.3	"	070	"	"	763
				0850	"	0.15	≤1	≤0.3	"	"	"	"	"
				0950	"	0.12	"	"	"	"	"	"	"
9	1.8	220	11/16	1050	"	0.74	20	5.0	3	020	"	"	"
				1120	"	0.80	3.7	1.3	"	"	"	"	"
				1150	"	0.25	45	5.4	4	"	10	"	"
				1220	"	0.54	21	5.0	"	"	"	"	"
				1250	"	0.48	≤1	0.8	"	"	9	"	762
				1320	"	2.3	8.5	3.6	"	"	"	"	"
				1350	"	4.4	2.3	1.0	5	"	"	"	"
				1425	"	0.34	2.8	1.6	"	"	"	"	"
				1500	"	0.28	"	0.8	"	"	"	"	"

Footnotes appear on the following page.

FOOTNOTES FOR TABLE 5.4.

[a]North - 360 degrees

[b]To convert to $\mu g/m^3$ at 25 C multiply ppbv by MC -- 5.46
CCl_4 -- 6.29
TCE -- 5.37
PCE -- 6.78

[c]General weather conditions: 11/15/76 Cloudy overcast, no sunshine, no precipitation.
11/16/76 Cloudy overcast, no sunshine, no precipitation.

[d]ND = not determined.

TABLE 5.5. ANALYSIS OF WATER, SOIL, AND SEDIMENT SAMPLES FROM HOOKER CHEMICAL (TRICHLOROETHYLENE PRODUCER)[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Water					
B-1	11/15/76	12/20/76	Light		0.5	1	16	0.8	Surface
B-2	11/15/76	12/15/76	Light		<5	535	9	3	Surface
B-3	11/15/76	12/16/76	Light		4	22	6	2	Surface
B-4	11/15/76	12/15/76	Heavy		3	249	4	<0.1	Surface
B-10	11/16/76	12/20/76	Medium		15	5227	24	6	Composite

Soil

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
B-5	0.208	18.1	ND[c]	2.7
B-6	0.205	22.0	ND	5.6
B-7	0.286	25.8	ND	2.7
B-8	0.278	23.1	ND	0.23

Sediment

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
B-1-S	0.206	37.8	1.46	0.18
B-2-S	0.235	27.3	0.84	0.63
B-3-S	0.567	26.6	0.42	≈0.030
B-4-S	0.328	86.0	ND	300

[a]Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b]Dry basis, ppb by weight.

[c]Practical detection limits; MC = 6 pg; TCE = 10 pg.

TABLE 5.6. DESCRIPTIONS OF SAMPLING LOCATIONS AT HOOKER CHEMICAL, HAHNVILLE, LOUISIANA (NOVEMBER 15-16, 1976)

Water

B1 - Surface sample, Mississippi River approximately 150 m upstream from the Hooker plant outfall; taken from furthest upstream point on Becker Fertilizer Plant dock; moderate current; turbid.

B2 - Surface sample, base of Hooker outfall pipe to Mississippi River; taken off dock approximately 6 to 8 m from shoreline; surface aerated at pipe base; barge being loaded at dock at time of sampling; moderate current; turbid.

B3 - Surface sample, approximately 1 km downstream of Hooker outfall in Mississippi River; taken from furthest upstream point off Union Carbide intake dock; barge moored 200 m upstream; moderate current; turbid.

B4 - Surface sample, open canal under Route 3127, 100 m west of bridge, 2 m wide, 0.5 m deep; abundant algae and duckweed; slow current, stagnant backwaters; gray-colored.

B10 - 24-Hour composite effluent sample collected from midnight November 14 to midnight November 15.

Sediment

B1S - Shoreline sample taken approximately 150 m upstream from Hooker outfall in Mississippi River; hard-packed clay/gumbo; dark gray/black with oily surface.

B2S - Shoreline sample taken 100 m downstream of Hooker outfall and dock in Mississippi River; much floating debris, white, frothy scum; hard-packed, dark-gray clay/gumbo; oily surface.

B3S - Shoreline sample taken 200 m downstream of Hooker outfall and dock in Mississippi River; hard-packed dark gray clay/gumbo.

B4S - Open canal under Route 3127, 100 m west of bridge; dark black aerobic ooze.

Soil

B5 - 50 m south off side of Route 3127 at bridge; corresponds to air sampling at site 5; moderate traffic; mostly sand, some clay.

B6 - 50 m north off route 3127 at substation gate; corresponds to air sampling site 6; moderate traffic; cultivated field; black loam.

B7 - 20 m east off Route 3142, 100 m south of State Route 18; grassy strip between Hooker Chemical and Union Carbide gates; periodically heavy traffic, many trucks; granular loam.

B8 - 2 m south off State Route 18 at power plant building site (much truck traffic); hard, root-bound, sandy soil with shells.

MONITORING DATA

PRODUCTION SITE 3

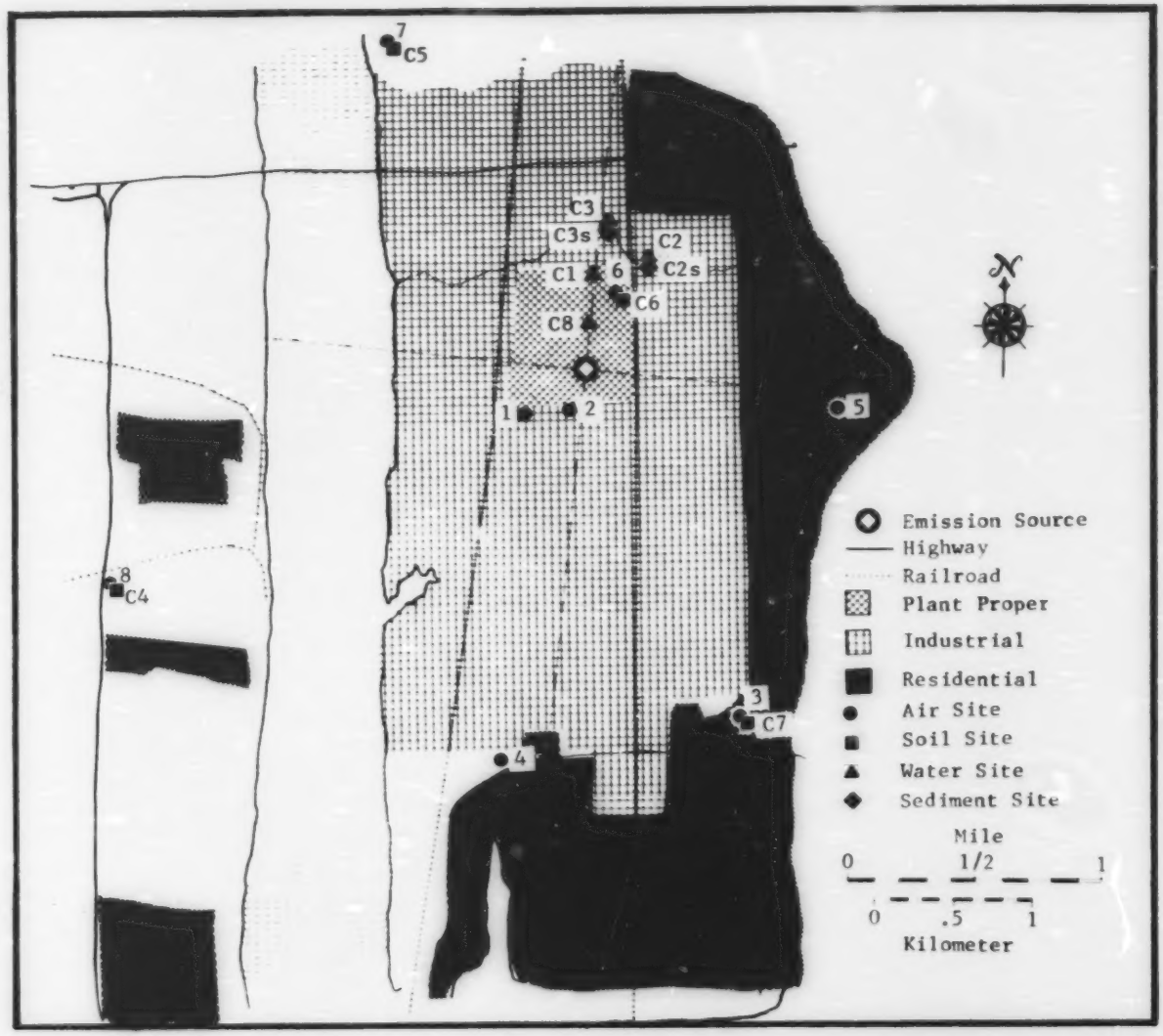


Figure 5.3. Sampling locations at Ethyl Corporation, Baton Rouge, Louisiana--trichloroethylene production site.

TABLE 5.7. AMBIENT AIR MEASUREMENTS AT ETHYL CORPORATION (TRICHLOROETHYLENE PRODUCER)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b]				Wind Speed, m/s	Meteorological Observations[c]			
					MC	CCl_4	TCE	PCE		Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
1	0.4	240	11/18	0815	≤0.3	7.3	5.6	5.2	4	020	14	ND[d]	761
				0845	"	1.9	1.9	1.6	"	"	"	"	"
2	0.2	195	11/18	0915	"	0.80	≤1	0.7	"	060	16	"	"
				0945	"	4.8	"	3.2	"	"	"	"	"
			11/19	0300	"	1.1	"	≤0.3	3	120	12	(trace)	758
				1014	"	2.4	5.4	5.1	4	030	11	"	"
				1100	"	47	7.2	37	"	060	"	(0.1)	"
				1200	"	0.90	2.4	8.5	"	030	"	(0.4)	"
3	2.4	150	11/18	1015	"	0.15	≤1	≤0.3	"	060	18	ND	761
				1730	"	0.16	"	"	0	360	17	"	759
				1800	"	0.12	"	"	"	"	"	"	"
				1930	"	"	"	0.5	2	"	"	"	"
				2000	0.6	0.13	"	0.6	"	"	"	"	"
				2030	1.1	0.15	"	"	0	"	16	"	"
				2100	1.0	"	"	"	"	"	"	"	"
				2130	1.5	0.21	"	1.0	"	"	"	"	"
				2200	1.0	0.33	"	"	"	"	"	"	"
				2230	--	0.26	"	0.8	"	"	"	"	"
				2300	2.2	--	"	0.6	"	"	"	"	"
				2330	3.9	0.52	"	0.4	"	"	"	"	"
				2400	0.6	0.50	"	"	1	140	14	"	"
			11/19	0030	1.5	2.7	"	0.5	0	360	"	"	"
				0100	0.9	1.9	"	≤0.3	"	"	"	(0.02)	"
				0130	"	1.3	"	"	"	"	12	ND	"
				0200	1.6	0.9	"	"	1	120	"	(0.02)	758
				0545	≤0.3	0.33	"	"	2	090	"	(0.2)	759
				0615	"	0.37	"	"	"	"	"	ND	"
				0700	"	0.32	"	"	4	060	10	(0.02)	758
				0730	"	0.26	"	"	"	070	"	ND	"
				0800	"	"	"	"	3	060	11	(trace)	"
				0830	0.5	0.22	"	"	"	"	"	ND	"

TABLE 5.7. (Continued)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
3	2.4	150	11/19	0900	≤0.3	0.21	≤1	≤0.3	4	060	11	(trace)	758
				0930	"	0.19	"	"	"	"	"	ND	"
				1000	"	0.18	"	"	"	030	"	(trace)	"
4	2.6	180	11/18	1055	"	0.12	"	"	2	020	18	ND	761
				1125	"	"	"	"	"	"	"	"	"
5	2.2	095	11/18	1155	"	0.11	"	"	1	070	"	"	"
				1225	"	0.17	"	"	"	"	"	"	"
6	0.7	010	11/18	1255	"	0.85	"	0.5	"	240	19	"	"
				1355	"	0.36	"	0.4	2	340	"	"	"
			11/19	0345	"	0.38	"	≤0.3	"	350	12	(trace)	758
				0415	"	1.3	"	0.6	"	"	"	ND	"
				0445	"	0.18	"	≤0.3	1	340	"	(0.07)	"
				0515	"	0.43	"	"	"	"	"	ND	"
7	2.2	330	11/18	1445	"	0.16	"	"	0	360	18	"	761
8	3.2	240	11/18	1545	"	0.14	"	"	2	080	"	"	"
				1615	"	0.13	"	"	"	"	"	"	"
			11/19	1300	"	0.67	"	"	4	040	11	(0.7)	757
				1330	"	0.17	"	"	"	"	"	ND	"

[a] North - 360 degrees.

[b] To convert to $\mu g/m^3$ at 25 C multiply ppbv by MC -- 5.46
CCl_4 -- 6.29
TCE -- 5.37
PCE -- 6.78

[c] General weather conditions: 11/18/76 Clear in morning becoming cloudy about 1400 hours with light, intermittent rain beginning about 2200 hours.
11/19/76 Cloudy all day, intermittent rain throughout the day.

[d] ND = not determined.

TABLE 5.8. ANALYSIS OF WATER, SOIL, AND SEDIMENT SAMPLES FROM ETHYL CORPORATION (TRICHLOROETHYLENE PRODUCER)[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Water					
C-1	11/18/76	12/22/76	Light	ND	74	128	105	67	
C-2	11/18/76	12/22/76	Heavy	Heavy	0.4	0.4	6	0.1	Surface
C-3	11/18/76	12/21/76	Heavy	Heavy	20	37	37	23	Surface
C-8	11/18/76	12/22/76	Clear	Light	10	10	32	12	Composite
C-9	11/19/76	12/22/76	Clear	ND	0.05	0.4	2	0.2	Tap water

Soil

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
C-4	0.246	26.3	0.20	ND[c]
C-5	0.261	20.5	0.25	ND
C-6	0.274	27.5	0.13	ND
C-7	0.192	17.3	0.28	ND

Sediment

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
C-2-S	1.07	27.2	0.81	ND
C-3-S	0.330	77.5	ND	116

[a]Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b]Dry basis, ppb by weight.

[c]Practical detection limits: MC = 6 pg; TCE = 10 pg.

TABLE 5.9. DESCRIPTIONS OF SAMPLING LOCATIONS AT ETHYL CORPORATION, BATON ROUTE, LOUISIANA (NOVEMBER 18-19, 1976)

Water

C1 - Effluent sample taken immediately above the settling pond weir to receiving bayou; strong aromatic odors; light blue-green color; very slippery feel.

C2 - Surface sample taken in receiving bayou 200 m upstream from plant outfall; 7 m wide, 0.5 to 1.5 m deep; moderate current; anaerobic odor; black, murky color with oil slick and tar globules on surface (bayou flaws through heavily industrialized area and under railroad tracks).

C3 - Surface sample taken in receiving bayou 300 m downstream from plant outfall; 7 m wide, 1 to 2 m deep; moderate flow; water quality appearance same as at C2 with additional slippery feel.

C8 - 24-hour composite effluent sample, 6:00 a.m. November 18 to 6:00 a.m. November 19, 1976.

C9 - Tap water from the Rodeway Inn, Baton Rouge, Louisiana.

Sediment

C2S - Upstream in receiving bayou 200 m from plant outfall; same location as water sample Site C2; taken 1 m from bank; aerobic, black, oily ooze.

C3S - Downstream in receiving bayou 300 m from plant outfall; same location as water sample Site C3; taken 0.5 m from bank; anaerobic, black, oily ooze.

Soil

C4 - Grave Plantation approximately 0.8 km west of Mississippi River; corresponds to air sampling Site 8; taken at edge of cane field; wet silt/gumbo.

C5 - 0.5 km east of dead end of Mengel Road (some industry and a tank-washing operation within 0.5 km radius); corresponds to air sampling Site 7; sample taken 5 m north off road in open field; loam.

C6 - Northeast corner of Ethyl parking lot on steep banks of bayou; much railroad traffic in immediate vicinity; hard clay.

C7 - Narrow (0.6 m) edge of parking lot at Istrouma Baptist Church; residential area, approximately 10 m from street; gravel, sand/rock.

MONITORING DATA

PRODUCTION SITE 4

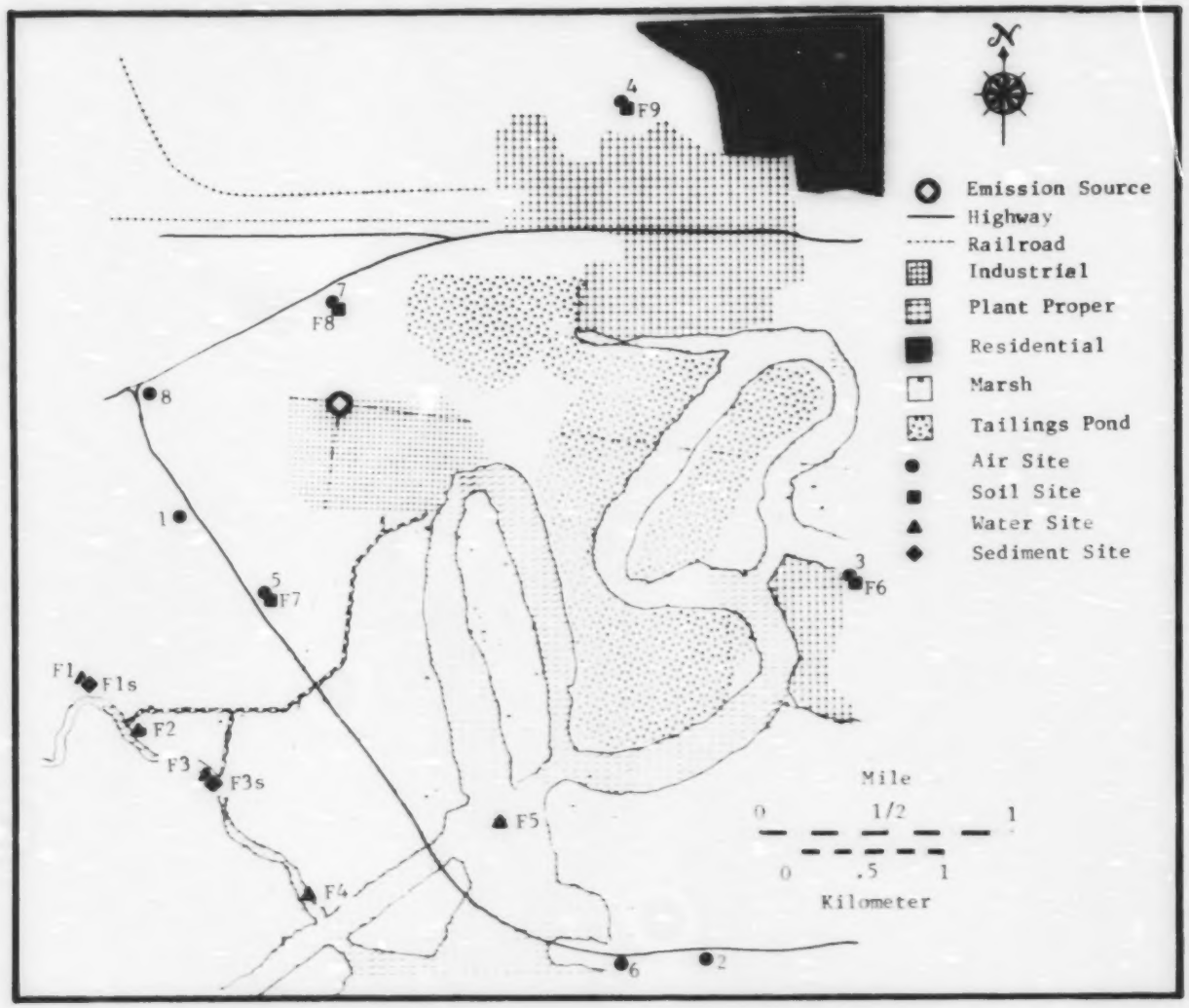


Figure 5.4. Sampling locations at PPG Industries, Lake Charles, Louisiana--trichloroethylene production site.

TABLE 5.10. AMBIENT AIR MEASUREMENTS AT PPG INDUSTRIES (TRICHLOROETHYLENE PRODUCER)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b]				Wind Speed, m/s	Meteorological Observations[c]			
					MC	CCl_4	TCE	PCE		Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
1	1.3	215	12/6	1014	1.3	0.24	2.7	0.4	8	150	15	87	755
				1043	0.8	0.17	2.2	0.3	"	"	"	"	"
2	4.2	140	12/6	1123	≤0.3	0.13	≤1	≤0.3	7	160	17	90	754
				1152	"	0.19	"	"	"	"	"	"	"
3	3.5	85	12/6	1302	"	0.13	"	"	9	"	"	87	753
				1330	"	0.20	"	"	"	"	"	"	"
			12/7	0900	0.7	0.24	"	0.4	7	340	6	76	759
4	2.7	40	12/7	1512	0.5	0.21	"	≤0.3	"	330	8	60	760
				1540	≤0.3	0.17	"	"	"	"	"	"	"
5	1.4	195	12/6	2100	"	0.18	"	"	10	360	14	80	756
				2129	"	0.15	"	"	"	"	"	"	"
				2157	"	"	"	"	"	350	12	"	"
				2226	"	0.17	"	"	9	"	"	77	"
				2254	"	0.20	"	"	"	"	"	"	"
6	4.0	150	12/6	2331	"	0.17	"	"	7	"	"	76	"
				2400	"	0.31	"	"	"	"	"	"	"
			12/7	0028	"	0.28	"	"	6	360	"	74	"
				0056	0.4	0.20	"	"	"	"	"	"	"
				0125	1.7	0.88	15	3.8	"	"	"	"	
				0153	≤0.3	0.19	≤1	0.4	7	"	11	80	757
				0222	"	0.20	"	≤0.3	"	"	"	"	"
				0249	1.5	0.64	6.6	2.5	6	340	9	"	"
				0317	5.0	0.21	≤1	≤0.3	"	"	"	"	"
				0345	8.5	0.31	2.2	0.7	7	"	8	"	"
				0413	0.7	0.19	≤1	≤0.3	"	"	"	"	"
				0441	≤0.3	0.20	"	"	"	"	7	79	758
				0509	6.5	0.92	12	5.0	"	"	"	"	"
				0537	≤0.3	0.15	≤1	≤0.3	6	350	6	"	"
				0605	1.4	0.17	"	"	"	"	"	"	"
				0633	1.2	0.26	"	"	7	"	"	"	"
				0701	1.4	0.17	"	"	"	"	"	"	"

TABLE 5.10 (Continued)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1976	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
6	4.0	150	12/7	0727	2.6	0.65	5.8	2.9	7	350	6	79	758
				0755	5.0	0.96	8.0	3.2	6	"	"	76	"
				0823	5.3	0.73	5.8	3.2	"	"	"	"	"
				0855	≤0.3	0.20	≤1	≤0.3	7	340	"	"	759
				0958	"	0.15	"	"	8	320	5	"	"
				1015	"	"	"	"	"	"	"	"	"
				1030	"	0.13	"	"	7	"	"	73	760
				1045	"	0.15	"	"	"	"	"	"	"
				1100	"	0.23	"	"	"	"	"	"	"
				1205	2.4	0.40	4.6	1.8	6	"	6	"	"
				1232	≤0.3	0.20	≤1	≤0.3	7	340	"	70	"
				1259	5.0	0.64	7.0	"	"	"	"	"	"
				1328	2.1	0.26	4.6	"	6	"	7	68	"
				1358	≤0.3	0.20	≤1	"	"	"	"	"	"
7	0.6	360	12/7	1030	"	0.21	"	"	7	320	6.7	73	"
8	1.3	265	12/7	1052	0.4	0.75	"	0.4	"	"	"	"	"

[a] North - 360°

[b] To convert to $\mu g/m^3$ at 25 C multiply ppbv by MC -- 5.46
CCl_4 -- 6.29
TCE -- 5.37
PCE -- 6.78

[c] General weather conditions: 12/6/76 Cloudy, rainfall recorded from 1000-2100 hours, very heavy at times.
12/7/76 Cloudy with very slight clearing in late afternoon; no precipitation.

TABLE 5.11. ANALYSIS OF WATER, SOIL, AND SEDIMENT SAMPLES FROM PPG INDUSTRIES (TRICHLOROETHYLENE PRODUCER)[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Water					
F-1	12/7/76	1/5/77	Heavy		132	353	11	29	
F-2	12/7/76	1/7/77	Heavy		181	447	85	40	
F-3	12/7/76	1/7/77	Heavy		58	179	30	12	
F-4	12/7/76	1/6/77	Heavy		161	403	34	38	
F-5	12/7/76	1/4/77	Heavy		5	29	12	<0.1	
F-10	12/7/76	12/13/77	Clear		0.3	0.1	<0.1	<0.1	Tap water

Soil

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
F-6	0.337	12.2	0.14	0.11
F-7	0.286	22.5	1.0	ND[c]
F-8	0.232	19.6	0.61	0.077
F-9	0.782	28.3	0.22	ND

Sediment

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
F-1-S	0.263	72.6	2.2	146
F-2-S	--[d]			
F-3-S	0.265	71.0	1.1	15
F-4-S	--[d]			

[a]Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b]Dry basis, ppb by weight.

[c]Practical detection limits: MC - 6 pg; TCE = 10 pg.

[d]Samples damaged in shipment (including duplicates).

TABLE 5.12. DESCRIPTIONS OF SAMPLING LOCATIONS AT PPG INDUSTRIES, LAKE CHARLES, LOUISIANA (DECEMBER 7, 1976)

Water

F1 - Surface sample, 50 m upstream from plant outfall in Bayou d'Inde; 10 m wide, 2.5 to 3 m deep; slow current; high conductivity (>8000 micromhox cm); dark-colored, turbid.

F2 - Surface sample, confluence of northernmost PPG effluent canal in Bayou d'Inde; 5 m wide, 1 m deep.

F3 - Surface sample, confluence of southernmost PPG effluent canal in Bayou d'Inde; 200 m below confluence of first canal (F2); 5 m wide, 1 m deep.

F4 - Surface sample, 50 m downstream of southernmost PPG effluent canal (F3) in Bayou d'Inde; 10 m wide, 2 to 3 m deep.

F5 - Surface sample, taken at mouth of Calcasieu River in Prien Lake, downstream of PPG outfalls.

F10 - Tap water taken from the Sheraton Motel, Lake Charles, Louisiana.

Sediment

F1S - 50 m upstream from plant outfall in Bayou d'Inde; black ooze.

F2S - Confluence of northernmost PPG effluent canal in Bayou d'Inde; black oily ooze.

F3S - Confluence of southernmost PPG effluent canal in Bayou d'Inde; black, oily ooze.

F4S - 50 m downstream of southernmost PPG effluent canal (F3) in Bayou d'Inde; black, oily ooze.

Soil

F6 - Lake Shore Drive near Port of Lake Charles; residential area; sand/clay roadfill.

F7 - I-210 drainage ditch 400 m north of bridge over Prien Lake; ditch composed of both concrete and sandy clay.

MONITORING DATA

USER SITE

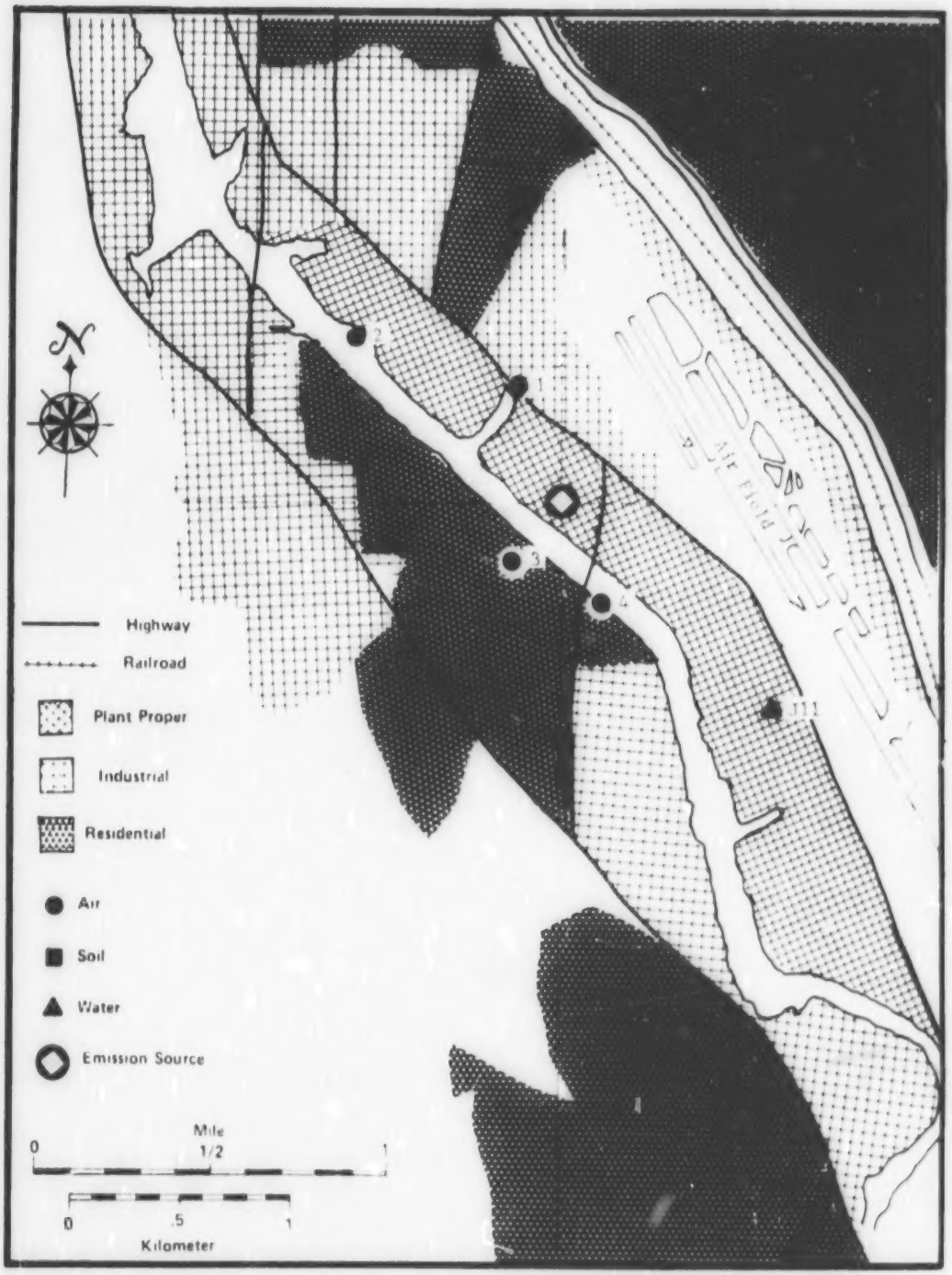


Figure 5.5. Sampling locations at Boeing Company, Seattle, Washington--trichloroethylene user site.

TABLE 5.13. AMBIENT AIR MEASUREMENTS AT BOEING/SEATTLE PLANT (TRICHLOROETHYLENE USER)

Site No.	Distance from Plant, km	Direction from Plant, degrees[a]	Date 1977	Time	Concentration in Ambient Air, ppbv[b] MC	CCl_4	TCE	PCE	Wind Speed, m/s	Meteorological Observations[c] Wind Direction, degrees[a]	Temperature, C	RH, %	Barometer, mm Hg
1	0.6	325	1/12	0920	0.20	0.10	0.10	0.12	2.0	180	415	93	758
2	1.1	290	1/12	0957	0.66	"	0.50	0.69	"	"	"	"	757
3	0.4	185	1/12	1035	0.28	0.09	38	0.40	1.7	360	3	"	"
				1055	0.32	0.10	17	1.1	"	"	"	"	"
4	0.5	140	1/12	1120	1.0	"	15	0.90	1.0	"	"	"	758
				1200	--	"	44	1.0	0.9	270	4	"	"
				1220	0.66	"	24	0.40	"	"	"	"	"

[a] North - 360 degrees.

[b] To convert to $\mu g/m^3$ at 25 C multiply ppbv by MC -- 5.46
CCL_4 -- 6.29
TCE -- 5.37
PCE -- 6.78.

[c] General weather conditions: Heavy cloud overcast, fog, light rain during entire sampling period.

[d] ND = not determined.

TABLE 5.14. ANALYSIS OF EFFLUENT SAMPLE FROM BOEING COMPANY SEATTLE, WASHINGTON (JANUARY 12, 1977)[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Effluent					
J-11[b]	1/12/77	2/9/77	Light	ND[a]	4	9	7	0.1	24-hour Composite

[a]Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b]This sample was provided from the plant.

MONITORING DATA

BACKGROUND SITE

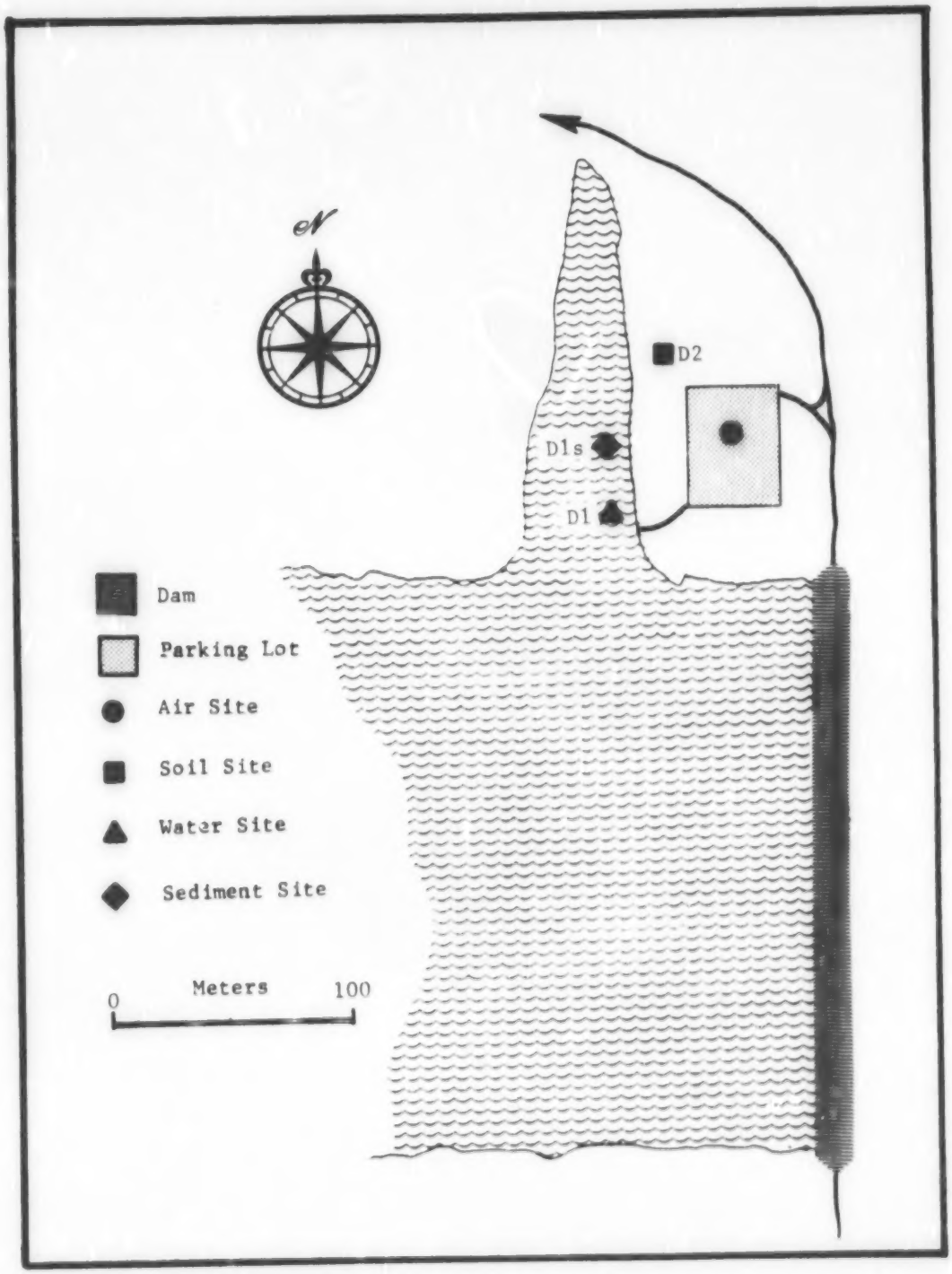


Figure 5.6. Sampling locations at St. Francis National Forest, Helena, Arkansas--background site.

TABLE 5.15 AMBIENT AIR MEASUREMENTS AT ST. FRANCIS NATIONAL FOREST (RURAL BACKGROUND)

Date	Time	Concentration in Ambient Air, ppbv[a]				Wind Speed, m/s	Meteorological Observations[c]			
		MC	CCl_4	TCE	PCE		Wind Direction, degrees[b]	Temperature, C	RH, %	Barometer, mm Hg
11/30/76	1030	≤0.3	0.15	≤1	≤0.3	1	170	3	41	761
	1055	"	"	"	"	"	"	"	"	"
	1125	"	0.13	"	"	"	"	"	"	"
	1146	"	0.14	"	"	2	210	5	38	760
	1216	"	0.15	"	"	"	"	"	"	"
	1243	"	0.12	"	"	3	230	4	39	"
	1308	"	0.11	"	"	"	"	"	"	"
	1334	"	0.14	"	"	"	225	5	42	759
	1400	"	"	"	"	"	"	"	"	"
	1426	"	0.13	"	"	"	"	4	44	"
	1452	"	0.15	"	"	4	220	"	"	"
	1517	"	0.14	"	"	"	"	"	"	"
	1545	"	0.15	"	"	3	160	"	49	"
	1611	"	0.14	"	"	"	"	"	"	"
	1636	"	"	"	"	2	165	2	58	"
	1700	"	0.15	"	"	"	"	"	"	"
	1730	"	"	"	"	"	"	1	66	"
	1800	"	0.14	"	"	"	"	"	"	"
	1825	"	0.15	"	"	"	"	"	"	"
	1850	"	0.14	"	"	"	160	"	70	"
	1917	"	"	"	"	"	"	"	"	"
	1955	"	0.15	"	"	4	170	2	73	758
	2022	"	"	"	"	"	"	"	"	"

[a] To convert to $\mu g/m^3$ at 25° C multiply by: MC -- 5.46; CCl_4 -- 6.29; TCE -- 5.37; PCE -- 6.78

[b] North - 360°

[c] General weather condition; 11/30/76 Clear, sunny, no precipitation.

TABLE 5.16. ANALYSIS OF WATER, SOIL, AND SEDIMENT SAMPLES FROM THE BACKGROUND SITE[a]

Sample No.	Date Sampled	Date Analyzed	Sediment in Sample	Sparging Foam	Concentration, ppb by weight MC	TCE	$CHCl_3$	CCl_4	Comments
				Water					
D-1	11/30/76	12/20/76	Clear	ND	0.4	<0.05	2	0.2	
D-3	11/30/76	12/14/76	Clear	ND	0.4	22	3	<0.1	Tap water

Soil

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
D-2	0.200	25.8	0.54	0.63
D-2	0.641	24.3	0.29	<0.42[c]

Sediment

Sample No.	Sample Weight, g	Water Content, %	Concentration, ppb[b] MC	TCE
D-1-S	0.198	45.0	0.67	2.2
D-1-S	0.115	54.0	0.23	ND[d]

[a]Notes: ND = none detected. See "Determination of Trichloroethylene in Water" for description of terms.

[b]Dry basis, ppb by weight.

[c]Possible interference present.

[d]Practical detection limits: MC = 6 pg; TCE = 10 pg.

TABLE 5.17. DESCRIPTIONS OF SAMPLING LOCATIONS AT STORM CREEK LAKE, ST. FRANCIS NATIONAL FOREST, HELENA, ARKANSAS, (NOVEMBER 30, 1976)

Water

D1 - surface sample taken from concrete boat dock on Storm Creek Lake, 100 meters south of parking lot; little wave action; clear.

D3 - tap water taken from the Holiday Inn, Helena, Arkansas.

Sediment

D1S - taken from boat dock on Storm Creek Lake, 100 meters south of parking lot; mud and sand with cover of light leaf litter; snail and mussell shells abundant.

Soil

D2 - west facing slope north of boat ramp; 75 meters west-southwest of parking lot; sandy humus with decomposing leaf litter and many roots; dense undergrowth of honeysuckle vines.